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Horizons of Insight:

Exploring the Frontiers of Multidisciplinary Science

2ND EDITION

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Edson Santos da Silva Júnior

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Science is a field of knowledge in which different disciplines intertwine to form a greater whole. **Horizons of Insight: Exploring the Frontiers of Multidisciplinary Science – 2 ed** is a work that expands this interconnection, bringing together 125 articles on various topics, written by experts from different knowledge.

Developed by **Seven Publications**, this book presents a broad overview of the challenges, discoveries and advances in fields such as mining sentiment in agribusiness news, snakebite accidents, nuclear energy and much more.

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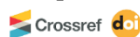
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ABSTRACT

This study investigates the correlation between the sentiment of specialized media and price formation in the poultry cluster of Bastos-SP, a hub responsible for approximately 11% of Brazilian egg production. The central objective of the work is to validate whether the information flow acts as a leading indicator or whether the local market operates decoupled from digital expectations due to physical fundamentals. The applied methodology, of an exploratory and quantitative nature, employs Natural Language Processing (NLP) techniques through the BERTimbau Deep Learning model to analyze a corpus of headlines collected between 2023 and 2026. The data were subjected to semantic filtering and weekly resampling using the Pandas library's ".resample('W')" method in Python. The results demonstrate that source curation and the removal of technical noise tripled the observed Pearson correlation (from $r = 0.04$ to $r = 0.12$), indicating that egg prices are marginally sensitive to macroeconomic factors rather than to zootechnical information. The weak, but positive, correlation ($r = 0.12$) observed after the inclusion of macroeconomic sources suggests that local producers are marginally more sensitive to structural trends (grain costs, external environment) than to zootechnical technical factors, which proved statistically irrelevant for short-term price forecasting. Therefore, it is concluded that the weak magnitude of the correlation confirms the dominance of the spot market and the biological nature of the asset, positioning media sentiment predominantly as a coincident indicator of market conditions.

Keywords: Sentiment Mining. BERTimbau. Agribusiness. Price Formation. Bastos-SP.

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RESUMO

Este estudo investiga a correlação entre o sentimento da mídia especializada e a formação de preços no *cluster* avícola de Bastos-SP, polo responsável por cerca de 11% da produção brasileira de ovos. O objetivo central do trabalho é validar se o fluxo informacional atua como um indicador antecedente ou se o mercado local opera descolado das expectativas digitais devido a fundamentos físicos. A metodologia aplicada, de caráter exploratório e quantitativo, emprega técnicas de Processamento de Linguagem Natural (PLN) por meio do modelo *Deep Learning* BERTimbau para analisar um *corpus* de manchetes coletadas entre 2023 e 2026. Os dados foram submetidos à filtragem semântica e reamostragem semanal por meio do método “.resample('W')” da biblioteca *Pandas* com programação em *Python*. Os resultados demonstram que a curadoria de fontes e a remoção de ruídos técnicos triplicaram a correlação de Pearson observada (de $r = 0,04$ para $r = 0,12$), evidenciando que o preço do ovo é marginalmente sensível a pautas macroeconômicas em detrimento de informações zootécnicas. A correlação fraca, porém, positiva ($r=0.12$), observada após a inclusão de fontes macroeconômicas, sugere que o produtor local é marginalmente mais sensível a tendências estruturais (custos de grãos, cenário externo) do que a pautas técnicas zootécnicas, que se mostraram estatisticamente irrelevantes para a previsão de preços de curto prazo. Conclui-se, portanto, que a magnitude fraca da correlação ratifica a dominância do mercado à vista (*spot market*) e a natureza biológica do ativo, posicionando o sentimento midiático predominantemente como um indicador coincidente das condições de mercado.

Palavras-chave: Mineração de Sentimento. BERTimbau. Agronegócio. Formação de Preços. Bastos-SP.

RESUMEN

Este estudio investiga la correlación entre el sentimiento de los medios especializados y la formación de precios en el *clúster* avícola de Bastos-SP, un centro que representa aproximadamente el 11% de la producción brasileña de huevos. El objetivo principal del trabajo es validar si el flujo informativo actúa como un indicador adelantado o si el mercado local opera desvinculado de las expectativas digitales debido a factores físicos fundamentales. La metodología aplicada, de carácter exploratorio y cuantitativo, emplea técnicas de procesamiento del lenguaje natural (PLN) mediante el modelo de aprendizaje profundo BERTimbau para analizar un *corpus* de titulares recopilados entre 2023 y 2026. Los datos fueron sometidos a filtrado semántico y remuestreo semanal utilizando el método “.resample('W')” de la biblioteca *Pandas* con programación en *Python*. Los resultados demuestran que la curación de fuentes y la eliminación del ruido técnico triplicaron la correlación de Pearson observada (de $r = 0,04$ a $r = 0,12$), lo que indica que los precios de los huevos son marginalmente sensibles a factores macroeconómicos más que a información zootécnica. La débil pero positiva correlación ($r = 0,12$) observada tras la inclusión de fuentes macroeconómicas sugiere que los productores locales son ligeramente más sensibles a las tendencias estructurales (costes de los cereales, entorno externo) que a los factores técnicos zootécnicos, los cuales resultaron estadísticamente irrelevantes para la previsión de precios a corto plazo. Por lo tanto, se concluye que la débil magnitud de la correlación confirma el predominio del mercado *spot* y la naturaleza biológica del activo, posicionando el sentimiento mediático predominantemente como un indicador coincidente de las condiciones del mercado.

Palabras clave: Análisis de Sentimiento. BERTimbau. Agroindustria. Formación de Precios. Bastos-SP.

1 INTRODUCTION

The municipality of Bastos-SP stands out as the largest poultry hub in the state of São Paulo, being responsible for approximately 45% of São Paulo's production and 11% of national egg production (MORAIS, 2025).

Recognized as the 'Capital of the Egg', according to Rodarte (2025), the region has an estimated daily production of 22 million units, which makes the financial sustainability of local producers dependent on efficiency in marketing and the ability to anticipate market volatilities.

The egg market, however, operates under *commodity* dynamics, characterized by narrow margins, high price volatility, and strong dependence on external factors, such as input costs and variations in demand (Dos Reis Filho et al., 2020). In this context, qualified information becomes an input as strategic as animal nutrition.

The poultry farmer's decision-making, historically based on experience and subjective intuition, today faces the challenge of predicting the price in a market increasingly dependent on external variables, requiring decisions based on economic and conjunctural analyses to the detriment of mere accumulated experience (EMBRAPA, 2024). In this scenario, the flow of digital news can influence trade expectations even before the facts materialize on the shelves.

In the Agriculture 4.0 scenario, data science has offered new perspectives for market intelligence. In a previous study, Morassuti and Neto (2025) demonstrated the feasibility of using *Google Trends* as a demand thermometer for the egg market in Bastos, showing that the volume of digital searches has a certain correlation with the local price dynamics. However, while *Google Trends* captures active user interest, there remains a gap in understanding how the provision of passive information, specifically the "tone" or sentiment of the specialized media, impacts asset pricing.

Advancing in this line of investigation, the present work is based on the premise that the media acts as a vector of expectations. Tetlock (2007) established the theoretical basis that the 'tone' of the news has predictive power over the financial market. Recently, Xu and Hsu (2022) validated this approach in the agricultural sector, demonstrating computationally that news-based sentiment indicators can capture price anomalies in agricultural products that escape traditional econometric models.

In view of this scenario, this article seeks to fill an informational gap on the efficiency of the physical market of perishable commodities, investigating the interdependence relationship between the sentiment expressed in the specialized media and the price fluctuation in the poultry cluster of Bastos-SP.

The originality of this research lies in the application of *Deep Learning* architectures (BERTimbau) in an over-the-counter market highly dependent on physical fundamentals, testing the boundary between media noise and the economic reality of the *analyzed cluster*. In addition to this introduction, the work is structured as follows: Section 2 details the methodological flow and data curation; Section 3 presents the results and the theoretical discussion in the light of the informational economy; and Section 4 summarizes the conclusions, limitations, and implications for agribusiness governance.

2 MATERIALS AND METHODS

To investigate the relationship between the sentiment expressed in agribusiness news and price fluctuation in the poultry sector of Bastos-SP, this study will employ an exploratory and quantitative approach, applying Natural Language Processing (NLP) techniques. As highlighted by Finatto, Lopes and Ciulla (2015), NLP seeks to create solutions to specific problems related to language recognition and reproduction, being a facilitating tool in the processing of large volumes of information.

The spatial cut comprises the production *cluster* of Bastos-SP, the largest poultry hub in the state of São Paulo, and the time frame covers the period from April 2023 to December 2026. The methodological flow was structured in four sequential stages: (i) Data Collection; (ii) Pre-processing; (iii) Sentiment Modeling via *Deep Learning*; and (iv) Statistical Correlation Analysis

2.1 DATA ACQUISITION AND CURATION

For the composition of the dependent variable (price), the daily historical series of the extra egg, white, in Bastos-SP, from the Center for Advanced Studies in Applied Economics (CEPEA, 2026), were extracted. These series allow us to monitor price dynamics and understand the sensitivity of the local market to external variables, whose daily variations reflect the direct influence of factors such as input costs and fluctuations in demand (CEPEA, 2026).

For the independent variable (feeling), a textual *corpus* was constituted from the collection of headlines from four news portals of high sectoral relevance: Avisite, Avinews, Canal Rural and Globo Rural (AVISITE, [n.d.]; AVINEWS, [n.d.]; CANAL RURAL, [n.d.]; GLOBO RURAL, [n.d.]). Unlike strictly automated approaches, we opted for manual data extraction and curation, aiming to establish a 'Gold Standard' of quality for the training and testing of NLP architecture.

This deliberate procedure allowed for rigorous semantic filtering through the standardized search term 'eggs', ensuring that the raw *dataset* of 636 records was free of institutional noise, social columns, or merely administrative edicts, elements that often compromise the accuracy of unsupervised *web scraping* algorithms.

2.2 SEMANTIC FILTERING AND NOISE TREATMENT

In order to ensure semantic relevance and data quality, an algorithmic filtering pipeline was applied. To this end, the *Pandas* library was used, which provides data structures and tools for the efficient manipulation of tables and time series, and is widely used in economic and market analysis (MCKINNEY; PANDAS DEVELOPMENT TEAM, 2026).

Through this tool, records containing terms associated with corporate events, sanitary management, or irrelevant niches, such as "vaccine", "pet", "congress", and "technology", were excluded. At the same time, an inclusion filter was applied to headlines containing economic markers, such as "price", "market", "export", "cost" and "supply".

This process refined the *original corpus*, resulting in 135 headlines of high economic relevance (N = 135).

2.3 SENTIMENT MODELING (BERT)

The polarity classification of the headlines was performed using the BERTimbau model (COSTA et al., 2020).

As highlighted by Costa et al. (2020), BERTimbau is the first language model pre-trained specifically for Brazilian Portuguese, achieving state-of-the-art results in various Natural Language Processing tasks.

The choice of this architecture is based on the robustness of systems based on *Bidirectional Encoder Representations from Transformers* (BERT) for capturing contextual nuances and its successful application in sentiment quantification aimed at modeling and predicting asset prices (CHAUDHRY, 2022).

Specifically, the *fine-tuned* nlptown/bert-base-multilingual-uncased-sentiment version was used, whose effectiveness for the classification of polarities in corpora of digital media and diversified databases was validated in recent comparative investigations, demonstrating high accuracy in identifying opinion trends (SAHOO et al., 2023).

The algorithm assigned a polarity score to each headline, which was later discretized into three classes: Negative (-1), Neutral (0), and Positive (1).

2.4 STATISTICAL ANALYSIS

Given the frequency discrepancy between the price data (daily) and the news (sporadic), the technique of weekly *resampling* (or weekly resampling) was used to harmonize the time series. The procedure was performed using the ".resample('W')" method of the *Pandas* library (MCKINNEY; PANDAS DEVELOPMENT TEAM, 2026), calculating the simple arithmetic mean of the variables for each epidemiological week.

It is noteworthy that weeks in which there was no information flow (news) were disregarded from the correlation analysis to avoid artificial neutrality bias, a procedure performed via the ".dropna()" function.

The validation of the influence hypothesis was performed through Pearson's Correlation Coefficient (), a parameter that measures the intensity and direction of the linear relationship between two quantitative variables, ranging from -1 to 1. Where a value close to 1 indicates strong positive correlation, -1 indicates strong negative correlation, and 0 indicates no linear relationship, testing the strength and direction of the linear relationship between the Weekly Sentiment Index and the Weekly Average Price of the physical asset.

3 RESULTS AND DISCUSSION

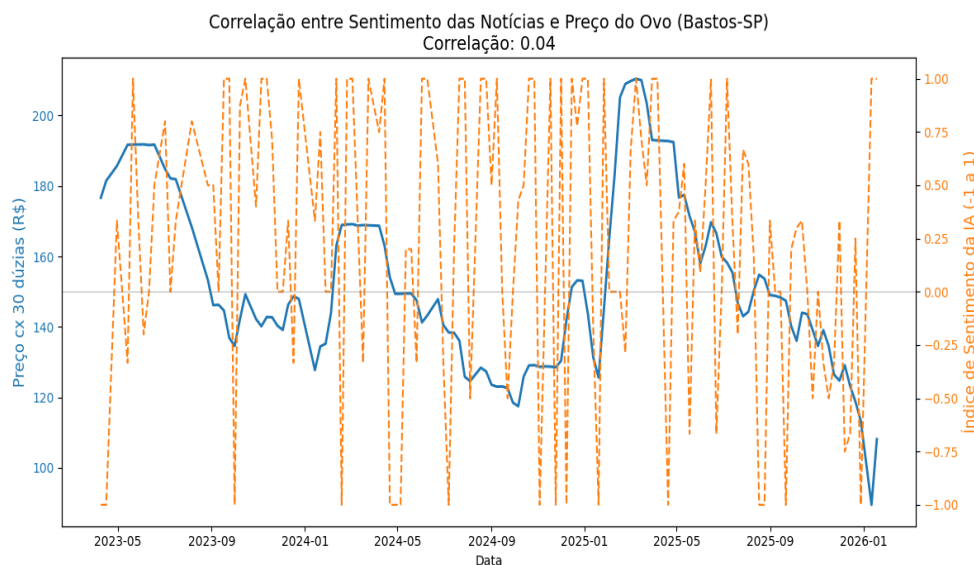
After the data collection stage, the analysis was structured into three distinct test scenarios to validate the consistency of the model.

In the first experimental scenario, which comprised the period from April 6, 2023 to January 16, 2026 using exclusively the technical portals Avinews and Avisite, it processed a raw *corpus* of 499 news items, resulting in a Pearson correlation of $r = 0.04$.

This result, illustrated in Figure 1, confirms that the flow of mostly technical and productive news has no explanatory power over the formation of prices in the short term for the *Bastos-SP* cluster.

Figure 1

Comparative time series between Average Price (CEPEA) and Sentiment (BERT) for the Avinews and Avisite portals (2023-2026). Correlation of 0.04.



Source: Prepared by the authors.

The second scenario incorporated semantic filtering (removal of institutional noise), reducing the sample to 65 news items, which marginally raised the correlation to 0.07.

Finally, the third scenario expanded the database by integrating macroeconomic sources (*Globo Rural* and *Canal Rural*), after filtering, a final *corpus* of 135 news items was obtained.

This scenario presented the highest correlation between the tests ($r=0.12$), a value that is still low, but significant compared to the previous scenarios, demonstrating that the curation of sources and semantic filtering contributed decisively to the qualification of the *dataset*.

Table 1 shows the analyzed test scenarios.

Table 1

Test scenarios carried out in the research and their correlations

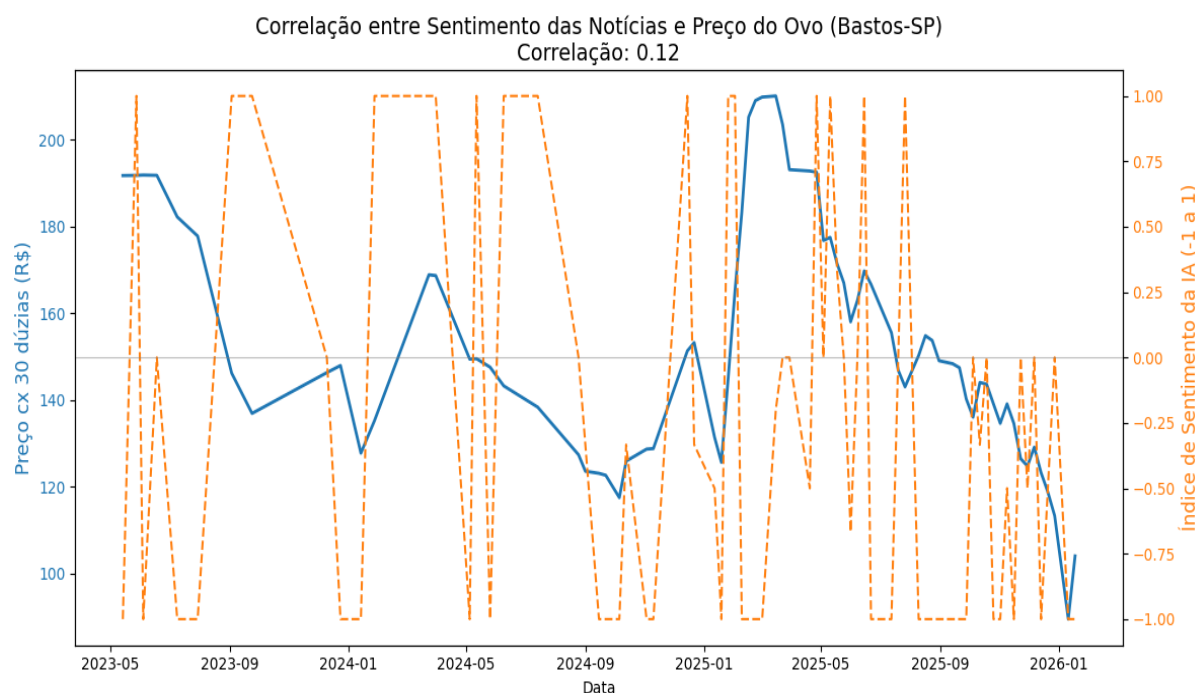
Test Scenario	News No.	Sources	Correlation (r)
Gross	499	0.04 (Null)	
Filtered	65	0.07 (Low)	
Multi-source	135	0.12 (Best)	

Source: Prepared by the authors.

The analysis of the time series, illustrated in Figure 2, reveals the dynamics between the Weekly Sentiment index (orange line) and the Average Price of Extra White Egg in Bastos-SP (blue line) over the period studied.

Figure 2

Comparative time series between the Average Egg Price (CEPEA) and the News Sentiment Index (NLP/BERT) in the period 2023-2025



Source: Prepared by the authors.

Visually, it is observed that the physical egg market presents high seasonal volatility, with characteristic peaks in the pre-Lent periods (February/March), driven by the increase in liturgical demand. The Sentiment index, in turn, demonstrates greater stability over time, reacting with intensity only to extreme events or macroeconomic shocks.

Quantitative statistical analysis corroborated this visual observation.

In the first experimental scenario, using the raw *dataset* (N=499) composed mostly of technical news from the Avisite portal, Pearson's correlation was statistically null (0.04). This indicates that the flow of news about management, health and technology has no explanatory power over price formation in the short term.

However, after the application of semantic filters and the integration of generalist sources (*Canal Rural* and *Globo Rural*), the *refined dataset* (N=135) presented a relevant qualitative change.

Pearson's correlation rose to 0.12. Although the magnitude of this correlation is still considered weak in the statistical literature, its multiplication by three times in relation to the base scenario (0.04-0.12) is a significant finding.

The analysis of the results shows a difference in the sensitivity of the market: the price of eggs in Bastos showed little sensitivity to news of a technical or productive nature ('inside the gate'). On the other hand, there was a slight reaction to macroeconomic variables ('out of the gate'), such as exchange rate fluctuations, input costs and export trends, frequent themes in the generalist portals analyzed.

However, the low correlation observed ($r < 0.20$) in all experimental scenarios ratifies the hypothesis that the Bastos pole operates under a predominantly physical dynamic, structurally diverging from the highly liquid financial markets.

While Tetlock's (2007) seminal literature establishes media sentiment as a leading indicator capable of predicting volatility in financial assets, the results obtained here suggest that, in laying poultry, news flow acts as a coincident indicator.

This distinction is based on the '*spot market dominance hypothesis*', in which the price formation of highly perishable products is governed by the urgency of physical settlement and daily inventories at the trading counter, rather than by speculative expectations (SHRESTHA et al., 2020).

Unlike financial assets that can be retained based on positive sentiments, the biological nature of the egg imposes a natural barrier to the spread of media noise: the price responds with greater elasticity to physical supply and demand shocks than to digital informational buzz (LI; WANG; DIERSEN, 2024).

Therefore, the weak magnitude of the correlation ($r = 0.12$) in the multisource scenario does not indicate a failure of the NLP model, but rather evidence of the informational efficiency of a market anchored in the physical reality of the gate.

4 FINAL CONSIDERATIONS

The present study sought to fill a gap in the market intelligence literature for agribusiness, applying Natural Language Processing (NLP) techniques to investigate the relationship between specialized media sentiment and price formation in the poultry cluster of Bastos-SP.

The results obtained allow us to conclude that, for the period analyzed (April 6, 2023 to January 16, 2026), the Alta Paulista egg market operates under a pricing dynamic predominantly based on immediate physical variables, demonstrating low elasticity in relation to the news flow.

The weak, but positive, correlation ($r=0.12$), observed after the inclusion of macroeconomic sources, suggests that the local producer is marginally more sensitive to structural trends (grain costs, external scenario) than to zootechnical guidelines, which proved to be statistically irrelevant for the short-term price forecast.

From a methodological point of view, the work validated the effectiveness of the use of Deep Learning models (BERTimbau) combined with rigorous semantic filters for the structuring of unsupervised data. The "cleaning" of institutional noise has proven essential to avoid false correlations, highlighting the importance of data curation in Big Data projects in Agribusiness.

As limitations, the time window of approximately three years and the exclusive focus on digital news portals are pointed out, which makes it impossible to capture informal flows in social networks that could contain more agile market signals.

In addition, the analysis was based on the processing of headlines; Although these summarize the main fact, the absence of the integral body of the news may omit relevant contextual nuances.

It is also noteworthy that the option for manual curation, although it has established a "gold standard" of quality and ensured the elimination of institutional noise, imposes restrictions on the scalability of the corpus analyzed.

For future studies, it is suggested the evolution of this model to a multivariate architecture, integrating the Sentiment Index developed here with climate variables, future quotations of inputs (corn and soybean) and search volume data (*Google Trends*). It is also recommended the application of time lag analysis to identify the exact interval of information absorption by the physical market of Bastos-SP, aiming at the construction of hybrid predictive models capable of overcoming the accuracy of traditional econometric methods.

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INCOME TRANSFER AND TERRITORIAL DEVELOPMENT: SOCIOECONOMIC IMPACTS OF THE GIRA RENDA PROGRAM IN PARAUAPEBAS (PA), BRAZIL

TRANSFERÊNCIA DE RENDA E DESENVOLVIMENTO TERRITORIAL: IMPACTOS SOCIOECONÔMICOS DO PROGRAMA GIRA RENDA EM PARAUAPEBAS (PA)

TRANSFERENCIA DE INGRESOS Y DESARROLLO TERRITORIAL: IMPACTOS SOCIOECONÓMICOS DEL PROGRAMA GIRA RENDA EN PARAUAPEBAS (PA), BRASIL



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ABSTRACT

This article analyzes the social and economic impacts of the Gira Renda Program in the municipality of Parauapebas (PA), Brazil, and discusses its contribution to Amazonian territorial development. The study adopts a qualitative and descriptive approach based on semi-structured interviews with a program manager and questionnaires applied to beneficiaries of public policy. The research aimed to understand both the direct social effects of income transfer policies and their indirect impacts on the local economy. The results indicate that the program contributed to reducing social vulnerability among beneficiary families, improving access to food, and strengthening food security. Furthermore, the use of the benefit in local commercial establishments stimulated the circulation of income within the municipality, contributing to the dynamization of local commerce and supporting small businesses. The analysis also highlights the predominance of women among beneficiaries, reinforcing the role of income transfer programs in addressing the feminization of poverty. However, the low monetary value of the benefit and the absence of complementary productive inclusion policies limit the program's potential for structural transformation. The

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findings suggest that income transfer policies may contribute to territorial development when articulated with solidarity economic initiatives, professional qualification programs, and strategies aimed at strengthening local economies.

Keywords: Income Transfer. Territorial Development. Solidarity Economy. Public Policy.

RESUMO

Este artigo analisa os impactos sociais e econômicos do Programa Gira Renda no município de Parauapebas (PA) e discute sua contribuição para o desenvolvimento territorial amazônico. A pesquisa possui abordagem qualitativa e descritiva, baseada na realização de entrevista semiestruturada com gestor do programa e na aplicação de questionários a beneficiários da política pública. O estudo buscou compreender tanto os efeitos sociais diretos da transferência de renda quanto seus impactos indiretos na economia local. Os resultados indicam que o programa contribuiu para reduzir a vulnerabilidade social das famílias beneficiárias, ampliar o acesso à alimentação e fortalecer a segurança alimentar. Além disso, a utilização do benefício em estabelecimentos comerciais do próprio município estimulou a circulação de renda no território, contribuindo para dinamizar o comércio local e fortalecer os pequenos negócios. A análise também evidencia a predominância de mulheres entre os beneficiários, reforçando o papel das políticas de transferência de renda na mitigação da feminização da pobreza. Entretanto, o baixo valor do benefício e a ausência de políticas complementares voltadas à inclusão produtiva limitam seu potencial de transformação estrutural. Conclui-se que programas de transferência de renda podem contribuir para o desenvolvimento territorial quando articulados a estratégias de economia solidária, qualificação profissional e fortalecimento das economias locais.

Palavras-chave: Transferência de Renda. Desenvolvimento Territorial. Economia Solidária. Políticas Públicas.

RESUMEN

Este artículo analiza los impactos sociales y económicos del Programa Gira Renda en el municipio de Parauapebas (PA), Brasil, y discute su contribución al desarrollo territorial amazónico. La investigación adopta un enfoque cualitativo y descriptivo basado en la realización de una entrevista semiestructurada con un gestor del programa y en la aplicación de cuestionarios a beneficiarios de la política pública. El estudio buscó comprender tanto los efectos sociales directos de la transferencia de ingresos como sus impactos indirectos en la economía local. Los resultados indican que el programa contribuyó a reducir la vulnerabilidad social de las familias beneficiarias, ampliar el acceso a la alimentación y fortalecer la seguridad alimentaria. Además, el uso del beneficio en establecimientos comerciales del propio municipio estimuló la circulación de ingresos dentro del territorio, contribuyendo a dinamizar el comercio local y fortalecer pequeños negocios. El análisis también evidencia la predominancia de mujeres entre los beneficiarios, lo que refuerza el papel de las políticas de transferencia de ingresos en la mitigación de la feminización de la pobreza. Sin embargo, el bajo valor del beneficio y la ausencia de políticas complementarias de inclusión productiva limitan su potencial de transformación estructural. Se concluye que las políticas de transferencia de ingresos pueden contribuir al desarrollo territorial cuando se articulan con estrategias de economía solidaria, capacitación profesional y fortalecimiento de las economías locales.

Palabras clave: Transferencia de Ingresos. Desarrollo Territorial. Economía Solidaria. Políticas Públicas.

1 INTRODUCTION

The persistence of social and territorial inequalities is one of the main challenges of public policies in contemporary Brazil. Although the country has made important progress in reducing poverty in recent decades, there are still strong socioeconomic disparities between regions and municipalities (Souza; Osório; Soares, 2019). In this context, income transfer programs have become relevant instruments of social protection. These policies seek to guarantee minimum subsistence conditions for populations in vulnerable situations.

In Brazil, the expansion of income transfer policies gained prominence from the 2000s onwards, especially with the implementation of the Bolsa Família Program. According to Lavinhas (2019), such policies contributed to reducing extreme poverty and expanding access to essential goods and services. In addition to the direct social effects, studies indicate that income transfer programs can generate indirect economic impacts. By increasing the income of beneficiary families, there is an increase in local consumption and stimulation of territorial economies (Gerard; Naritomi; Silva, 2021).

These effects can be analyzed from the perspective of territorial development. Unlike traditional approaches to economic development, this perspective considers the territory as a space of interaction between social actors, institutions, and productive activities. In this sense, public policies can contribute to strengthening local economies and reducing regional inequalities (Monteiro Neto; Columbus; Rocha Neto, 2020).

In the Amazonian context, this discussion takes on particular relevance. Municipalities that have high economic dynamism associated with the exploitation of natural resources often coexist with persistent social inequalities. This phenomenon is common in mining municipalities in the Brazilian Amazon. In these territories, the expansion of mining generates significant economic growth, but does not always promote proportional improvements in the living conditions of the population (Monteiro Neto; Columbus; Rocha Neto, 2020).

The municipality of Parauapebas, located in the southeast of the state of Pará, represents an emblematic case of this dynamic. The presence of the Carajás mining complex has transformed the municipality into an important center of mineral production. This activity generated strong economic growth and increased municipal revenue. However, this process was also accompanied by relevant social challenges. Among them, the accelerated urban expansion and the persistence of pockets of poverty in peripheral areas stand out (Costa; Jesus, 2020).

In this scenario, municipal public policies aimed at reducing social vulnerability become fundamental. Among these initiatives, the Gira Renda Program stands out. It is a municipal public policy aimed at the direct transfer of income to families in poverty. The main

objective of the program is to increase food security and reduce economic vulnerability.

In addition to its direct social impacts, the program has characteristics that allow it to be analyzed from the perspective of territorial development. The benefit must be used in commercial establishments registered in the municipality itself. In this way, the policy stimulates the circulation of income in the territory and strengthens small local businesses. This mechanism brings the program closer to experiences related to solidarity economy and territorial finance (Singer, 2018; Morais; Costa, 2021).

In this context, this article aims to analyze the social and economic impacts of the Gira Renda Program in the municipality of Parauapebas (PA). To this end, a structured questionnaire was applied to the beneficiaries and a semi-structured interview with the program manager. In addition, documentary analysis of institutional materials related to the Gira Renda Program was carried out. With this work, we seek to discuss how this public policy contributes to the Amazonian territorial development.

2 THEORETICAL FRAMEWORK

2.1 INCOME TRANSFER AND POVERTY REDUCTION POLICIES

Income transfer policies have been widely used as instruments to combat poverty and reduce social inequalities in several countries. These policies consist of the direct transfer of financial resources to families in vulnerable situations, with the aim of ensuring minimum subsistence conditions and expanding access to essential goods and services. According to Lavinhas (2019), cash transfer programs have become central components of contemporary social protection systems, especially in countries marked by high levels of socioeconomic inequality.

In Brazil, these policies gained greater relevance from the 2000s onwards, with the implementation of programs aimed at direct income transfer to low-income families. Souza, Osório and Soares (2019) highlight that the expansion of these programs has contributed significantly to the reduction of poverty and income inequality in the country. In addition, such policies have also expanded access to basic public services, such as education and health, contributing to improving the living conditions of the most vulnerable populations.

Another important aspect refers to the impact of these policies on the food conditions of beneficiary families. Studies indicate that income transfer programs contribute to reducing food insecurity and improving the nutritional conditions of populations in situations of social vulnerability. In this sense, Mattei (2019) argues that the direct transfer of resources allows for increased food consumption and ensures greater food security for beneficiary families.

In addition to the direct social impacts, recent research indicates that income transfer programs can also generate indirect economic effects. By increasing the disposable income of beneficiary families, there is an increase in local consumption and stimulation of commercial activities and services. Gerard, Naritomi, and Silva (2021) demonstrate that cash transfers can produce multiplier effects on local economies, contributing to boosting small-scale economic activities.

2.2 TERRITORIAL DEVELOPMENT AND PUBLIC POLICIES

The concept of territorial development, according to Monteiro Neto, Colombo and Rocha Neto (2020), emerges as an alternative to traditional approaches to economic development based exclusively on economic growth indicators. From this perspective, development is understood as a multidimensional process that involves economic, social, institutional and spatial aspects. For the authors Monteiro Neto, Colombo and Rocha Neto (2020), territory is the space of interaction between social actors, institutions and productive activities.

In this context, public policies can play an important role in promoting territorial development. By stimulating local economic activities and expanding opportunities for social inclusion, these policies contribute to reducing regional inequalities and strengthening territorial economies. According to Monteiro Neto, Colombo and Rocha Neto (2020), territorial development depends on the ability to articulate public policies, local economic initiatives and social participation.

In the Brazilian case, territorial inequalities are strongly related to the concentration of economic activities and the unequal distribution of infrastructure and public services. Municipalities located in peripheral regions or dependent on extractive activities often show economic growth accompanied by persistent social inequalities. This dynamic reinforces the importance of public policies aimed at promoting more balanced territorial development (Araújo, 2019).

The literature highlights that territorial development involves processes of social and institutional construction that depend on the participation of different local actors. In this sense, public policies can act as instruments for coordinating and promoting development strategies capable of strengthening the economic and social capacities of the territories (Dallabrida, 2020).

2.3 SOLIDARITY ECONOMY AND CIRCULATION OF INCOME IN THE TERRITORY

The solidarity economy has been pointed out as a relevant strategy to promote productive inclusion and strengthen territorial economies. Unlike traditional forms of economic organization, based on competition and profit maximization, the solidarity economy is based on principles of cooperation, self-management and solidarity. Singer (2018) highlights that solidarity economy initiatives can expand opportunities for job and income generation, especially in contexts marked by social inequalities.

Cooperatives, productive associations and solidarity economy networks are instruments capable of strengthening economic relations based on cooperation among participants. According to Morais and Costa (2021), these initiatives contribute to strengthening territorial economic circuits and expanding opportunities for productive inclusion in local communities.

Another important aspect refers to the circulation of income within the territory itself. Solidarity economy experiences often seek to stimulate consumption in local establishments, reducing dependence on external economic flows. In this sense, França Filho and Laville (2020) argue that the local circulation of resources is a central element for strengthening territorial economies and promoting sustainable socioeconomic development.

In this context, the articulation between income transfer policies and solidarity economy initiatives can amplify the impacts of these policies on territorial development. By stimulating consumption in local establishments and strengthening community economic networks, these policies contribute to boosting territorial economies and expanding opportunities for productive inclusion (Morais; Costa, 2021).

2.4 MINING, INEQUALITY AND TERRITORIAL DEVELOPMENT IN THE AMAZON

In the Amazonian context, the relationship between economic growth and social inequality has specific characteristics. Municipalities that have strong economic dynamism associated with the exploitation of natural resources often coexist with persistent social inequalities. Monteiro Neto, Colombo and Rocha Neto (2020) highlight that municipalities dependent on extractive activities tend to present high economic growth accompanied by fragility in the local productive structure.

The expansion of mining in the Brazilian Amazon has generated significant economic growth in several municipalities, especially those located in areas of mineral exploration. However, this growth has not always been accompanied by proportional improvements in the living conditions of the local population. According to Costa and Jesus (2020), mining

municipalities often have significant social inequalities, associated with income concentration and dependence on extractive activities

This phenomenon has also been described in the literature as a development model based on economic enclaves, in which extractive activities generate a large volume of wealth with reduced local productive chains. As a result, economic growth can coexist with high levels of poverty and social inequality in mining territories (Monteiro Neto; Columbus; Rocha Neto, 2020).

In this scenario, public policies aimed at reducing social vulnerability become fundamental. Income transfer programs can contribute to reducing social inequalities and stimulating the circulation of resources in the local economy. Gerard, Naritomi, and Silva (2021) highlight that the increase in the income of beneficiary families tends to stimulate local consumption, strengthening small commercial establishments and boosting territorial economies.

In this way, income transfer policies can contribute to broader processes of territorial development, especially when articulated with strategies of productive inclusion, solidarity economy, and strengthening of local economies (Morais; Costa, 2021).

3 METHODOLOGY

The present research is characterized as applied, descriptive in nature and with a qualitative approach. According to Gil (2019), descriptive research aims to analyze characteristics of a certain phenomenon or population, seeking to understand relationships and patterns present in the investigated reality. This study sought to analyze the social and economic impacts of the Gira Renda Program in the municipality of Parauapebas (PA) and discuss its contribution to territorial development.

The qualitative approach was adopted because it allows us to understand perceptions, experiences and interpretations of the subjects involved in the public policy analyzed. According to Minayo (2021), qualitative research makes it possible to investigate complex social phenomena based on the interpretation of the meanings attributed by individuals to their experiences. Thus, this type of approach is adequate to analyze public policies and their effects on the living conditions of the population.

The research was carried out in the municipality of Parauapebas, located in the southeast of the state of Pará, a region characterized by strong economic dynamism associated with mining activity. Despite the economic growth observed in recent decades, the municipality presents important challenges related to social inequality and the economic vulnerability of portions of the population.

Data collection was carried out using two main instruments: a structured questionnaire applied to the beneficiaries and a semi-structured interview with the program manager. The fieldwork was carried out in 2025, with the application of the questionnaires between the months of March and April. The sample population was composed of beneficiaries of the Gira Renda program and the selection of participants occurred in a non-probabilistic manner, considering the availability and access to the respondents.

The questionnaire sought to identify the socioeconomic profile of the beneficiaries, as well as to understand how the benefit received contributed to improving their living conditions. A total of 20 responses were collected. The interview aimed to understand institutional aspects related to the implementation of the program, including its objectives, functioning and challenges

In addition to the collection of primary data, documentary analysis of institutional materials related to the Gira Renda Program was also carried out, including municipal legislation, institutional reports and information made available by public agencies. Document analysis allows us to complement the information obtained through interviews and questionnaires, contributing to broaden the understanding of the investigated phenomenon (Gil, 2019).

The data obtained through the questionnaires and interviews were analyzed using the content analysis technique. According to Bardin (2016), content analysis consists of a set of systematic procedures for analyzing communications, allowing the identification of categories and patterns present in the data collected. In this study, the information was organized into analytical categories related to the socioeconomic profile of the beneficiaries, the social impacts of the program, and the territorial economic effects associated with the public policy.

During the manuscript preparation process, a generative artificial intelligence tool (ChatGPT, developed by OpenAI) was used to support textual revision, structural organization of the text, and improvement of academic writing. The tool was used exclusively as an auxiliary writing resource, and was not used for the analysis of the empirical data of the research or for the formulation of the results presented in the study.

The interpretation of the data, the construction of the analytical categories and the conclusions of the research were carried out entirely by the authors, ensuring academic responsibility for the scientific content of the work. The use of the tool followed principles of transparency and good practices in the use of digital technologies in scientific production.

Finally, it is noteworthy that the research respected the ethical principles related to the confidentiality of information and the preservation of the identity of the participants, ensuring that the data collected were used exclusively for academic purposes.

4 RESULTS AND DISCUSSION

This section presents the results obtained from the application of the questionnaires to the beneficiaries of the Gira Renda Program and from the interview conducted with a former manager of the program. The information was organized into analytical tables that allow understanding the socioeconomic profile of the beneficiaries, the social impacts of the program and its possible implications for the local economic dynamics.

The discussion of the results was carried out in dialogue with the literature on income transfer policies, solidarity economy, and territorial development, seeking to interpret how the public policy analyzed contributes to reducing social vulnerabilities and stimulating the circulation of income in the territory (Lavinias, 2019; Monteiro Neto; Columbus; Rocha Neto, 2020).

The data indicate that the Gira Renda Program produced relevant impacts on the daily lives of beneficiary families. The cash transfer contributed to expanding access to essential goods. These results are consistent with studies that indicate that income transfer policies act as instruments of social protection and reduction of immediate economic deprivation (Lavinias, 2019; Mattei, 2019).

In addition to the direct social effects, the results suggest indirect impacts on the local economy. The use of the benefit in commercial establishments registered in the municipality stimulated local consumption, contributing to boost small and medium-sized businesses. As Gerard, Naritomi and Silva (2021) argue, the increase in the disposable income of beneficiary families can generate multiplier effects on local economies, strengthening commercial activities and services.

However, the data also show structural limitations of public policy. The relatively low value of the benefit and the absence of complementary policies for productive inclusion reduced the potential for structural transformation of the program. In this sense, several authors highlight that income transfer programs have more lasting impacts when articulated with strategies for professional qualification, solidarity economy, and strengthening of local economies (Singer, 2018; Morais; Costa, 2021).

Table 1 presents a summary of the main information obtained in the interview with a former manager of the Gira Renda Program. The analysis of the report allowed us to understand institutional aspects related to the creation, operation and impacts of the program in the municipality of Parauapebas. In addition, the interview contributed to identifying structural limitations and administrative challenges that influenced the implementation of public policy, as well as perspectives for the improvement of future initiatives aimed at reducing social vulnerability and strengthening territorial development.

Table 1

Summary table of the main information obtained in the interview with the manager

Analysis Category	Key information from the interview	Analytical interpretation
Objective of the program	The Gira Renda Program was created with the objective of reducing the social vulnerability of low-income families in Parauapebas through the monthly transfer of financial resources.	The policy was conceived as an instrument of social protection and fight against poverty. Income transfer programs are recognized in the literature as relevant mechanisms for reducing poverty and expanding access to essential goods and services (Lavinias, 2019; Souza; Osório; Soares, 2019).
Target audience	Families in vulnerable situations registered in the Unified Registry, with priority given to low-income families, the presence of children and people at social risk.	The prioritization of vulnerable families is in line with the targeting strategies of social assistance policies in Brazil, which seek to direct public resources to groups at higher risk of social exclusion (Silva; Yasbek; Giovanni, 2012).
Benefit amount	The monthly benefit granted to families was approximately R\$ 100.00 , made available through an electronic card for use in commercial establishments registered in the municipality.	Even low-value benefits can contribute to reducing immediate deprivations and expanding access to essential goods, especially in contexts of poverty and food insecurity (Lavinias, 2019; Mattei, 2019).
How it works	The resource was used exclusively in commercial establishments registered in the municipality.	This mechanism stimulates the circulation of income in the territory and strengthens local commerce, generating multiplier effects on the local economy (Gerard; Naritomi; Silva, 2021).
Impacts perceived by management	The former manager highlighted improvements in the food conditions of families and greater movement in local commerce.	Income transfer programs tend to increase the consumption of beneficiary families and stimulate local economic activities, contributing to boost territorial economies (Gerard; Naritomi; Silva, 2021; Lavinias, 2019).
Program limitations	The value of the benefit was considered low in view of the increase in the cost of living and budgetary limitations to expand the number of beneficiaries.	The literature highlights that income transfer policies have a greater impact when associated with other strategies for productive inclusion and income generation (Souza, 2019; Mattei, 2019).
Administrative challenges	Administrative changes and contractual limitations affected the continuity of the program.	Institutional fragility and the discontinuity of public policies are factors often pointed out as obstacles to the consolidation of territorial development strategies (Dallabrida, 2020).
Future prospects	The former manager highlighted the importance of resuming the program associated with professional qualification and productive inclusion actions.	The articulation between income transfer, solidarity economy, and productive inclusion policies can amplify the impacts of these policies on territorial development (Singer, 2018; Moraes; Costa, 2021).

Source: Organization of the authors through information from the interview conducted with a former manager of the Gira Renda Program in 2025 (2026)

Table 2 presents the socioeconomic profile of the beneficiaries of the Gira Renda Program participating in the research. The data indicate a predominance of women among the respondents, in addition to low family income and a high degree of socioeconomic vulnerability.

Table 2

Socioeconomic profile of the beneficiaries of the Gira Renda Program participating in the research (n = 20)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Women	15	75
	Male	5	25
Age group	30–39 years old	8	40
	40–49 years old	5	25
	Other age groups	7	35
Number of children	1 child	4	20
	2 children	8	40
	3 children	5	25
	4 children or more	3	15
Length of residence in Parauapebas	5 to 10 years	4	20
	10 to 15 years	5	25
	15 to 20 years	7	35
	More than 20 years	4	20
Current household income	Less than 1 minimum wage	8	40
	1 minimum wage	10	50
	Up to 2 minimum wages	2	10

Source: Elaboration by the authors based on data from the research carried out in 2025 (2026).

There was a predominance of women among the respondents (75%), evidencing the role of women in managing family income and coping with situations of social vulnerability. Regarding the age group, 65% of the participants are between 30 and 49 years old, indicating that the program mainly serves people of economically active age.

This pattern is also observed in cash transfer programs in different contexts, in which women tend to be the main beneficiaries of social policies (Lavinias, 2019). According to Souza, Osório and Soares (2019), prioritizing women in income transfer programs contributes to increasing food security and improving the management of resources within the family.

Regarding family income, the results indicate that 90% of the interviewees have an income equal to or less than one minimum wage, evidencing a context of strong socioeconomic vulnerability. This scenario reinforces the importance of public income transfer policies as instruments to support families in situations of poverty and social exclusion.

4.1 SOCIAL AND ECONOMIC IMPACTS OF THE PROGRAM

Table 3 presents the main social impacts perceived by the beneficiaries of the Gira Renda Program.

Table 3

Main social impacts perceived by the beneficiaries of the Gira Renda Program (n = 20)

Perceived impact	Response Category	Frequency (n)	Percentage (%)
Improving family income	Yes	11	55
	Partially	6	30
	No	3	15
Sufficiency of the amount received	Sufficient	8	40
	Partially sufficient	9	45
	Insufficient	3	15
Perception of improvement in the community	Yes	11	55
	No	3	15
	They did not know how to evaluate	6	30
Overall evaluation of the program	Great	9	45
	Good	8	40
	Regular	3	15

Source: Survey data (2025).

It is observed that 55% of the interviewees stated that they had noticed an improvement in family income, while 30% indicated partial improvement and only 15% did not identify significant changes. This result confirms the importance of cash transfer programs as instruments for immediate poverty alleviation, especially in contexts of social vulnerability. According to Lavinás (2013), income transfer policies have the capacity to reduce economic deprivation in the short term, contributing to improving the minimum subsistence conditions of families.

In addition, Silva and Yasbek (2017) highlight that programs of this nature act as social protection mechanisms, guaranteeing a minimum income for populations in vulnerable situations. In this sense, even relatively modest amounts can play an important role in reducing economic insecurities, especially when directed to low-income families with a high number of dependents.

Regarding the sufficiency of the amount received, the results show that 45% of the beneficiaries considered the resource only partially sufficient. This data reinforces one of the main criticisms present in the literature on income transfer policies: the limitation of the impact when the values do not follow the changes in the cost of living. According to Souza (2019), income transfer programs are fundamental for social protection, but they need to be articulated with other public policies, such as professional training and productive inclusion, to produce more lasting structural effects.

Another relevant aspect refers to the perception of changes in the community, identified by 55% of the interviewees. This result suggests that the program not only impacted the beneficiary families, but also contributed to boosting the local economy. As Sen (1999) argues, public policies aimed at expanding individual capacities can generate positive

collective effects, strengthening the social and economic development of the territories.

In the context of Parauapebas, this territorial effect becomes even more significant, as the program directed consumption to small and medium-sized commercial establishments in the municipality. According to Singer (2002), initiatives that stimulate the circulation of resources in one's own territory can strengthen local economies, generate dynamism in commerce and expand opportunities for social inclusion.

In addition to the economic impacts, the results indicate that the benefit contributed to improving food conditions and helping to pay basic expenses for beneficiary families. This result is in line with studies that show that cash transfer programs contribute to the reduction of food insecurity and to the improvement of the living conditions of families in vulnerable situations (Mattei, 2019). Likewise, Lavinás (2019) highlights that this type of policy has a direct impact on the ability of families to meet basic needs, especially in contexts of poverty and social exclusion.

Another relevant result refers to the general evaluation of the program, in which 85% of the participants classified the initiative as "good" or "excellent". This result shows the social recognition of the public policy among the beneficiaries. As Souza (2006) argues, public policies that respond directly to the needs of the population tend to generate greater social legitimacy and greater recognition by the beneficiaries.

Finally, it is noteworthy that 90% of the interviewees stated that they would like the program to return, evidencing the importance of Gira Renda for the daily lives of the families served. This result reinforces that income transfer policies continue to be perceived as relevant instruments to address social inequalities, especially in municipalities marked by strong economic dynamism, but also by high levels of social inequality, as is the case of Parauapebas.

Thus, the results indicate that the Gira Renda Program played an important role in reducing social vulnerabilities and expanding access to minimum conditions for survival. However, they also highlight the need for integration with other public policies for productive inclusion and territorial development, in order to expand their transformative potential.

4.2 CONTRIBUTIONS TO TERRITORIAL DEVELOPMENT

Table 4 summarizes the empirical evidence observed in the research, indicating that the Gira Renda Program produced relevant impacts both in the social sphere and in the local economic dynamics.

Table 4

Empirical evidence of the impacts of the Gira Renda Program

Dimension analysed	Empirical evidence from the research	Theoretical interpretation
Socioeconomic profile	Predominance of women (75%) and family income mostly less than one minimum wage.	The predominance of women among beneficiaries highlights the feminization of poverty and the role of income transfer policies in expanding women's economic autonomy (Lavinias, 2019).
Improving family income	55% of respondents reported an improvement in income and 30% a partial improvement.	Cash transfer programs contribute to reducing immediate economic vulnerabilities and increasing the consumption of beneficiary families (Mattei, 2019).
Food safety	Beneficiaries reported using the benefit mainly for food.	Income transfer contributes to reducing food insecurity and expanding access to essential goods (Silva; Yasbek; Giovanni, 2012).
Impacts on the local economy	The benefit was used in commercial establishments in the municipality itself.	The expansion of household consumption can generate multiplier effects on the local economy (Gerard; Naritomi; Silva, 2021).
Program evaluation	85% evaluated the program as good or great and 90% want its return.	The high social approval indicates recognition of the importance of public policy for beneficiary families (Souza, 2006).
Identified limitations	Value of the benefit considered low and absence of complementary actions for productive inclusion.	Income transfer programs have the greatest impact when articulated with income generation and solidarity economy policies (Singer, 2018; Morais; Costa, 2021).

Source: Elaboration by the authors based on research data in 2025 and the literature on income transfer policies and territorial development (2026)

The analysis presented in Table 4 confirms the role of the program in reducing social vulnerabilities and boosting local economic dynamism. Table 5 presents an analytical model that summarizes the mechanisms through which income transfer policies can contribute to territorial development processes.

Table 5

Analytical model: income transfer and territorial development

Process step	Policy mechanism	Observed results	Theoretical contribution
Income transfer	Monthly benefit intended for families in situations of social vulnerability.	Improvement in family income and greater consumption capacity.	Instrument for social protection and poverty reduction (Lavinias, 2019).
Circulation of income in the territory	Use of the benefit in local establishments.	Strengthening of local commerce.	Multiplier effects on the territorial economy (Gerard; Naritomi; Silva, 2021).
Local economic dynamism	Expansion of the demand for goods and services in small businesses.	Increased economic movement in the communities.	Strengthening of territorial economies (Monteiro Neto; Columbus; Rocha Neto, 2020).
Integration with solidarity economy	Potential articulation with cooperatives, associations and local initiatives.	Stimulus to the local circulation of resources.	Solidarity economy as a strategy for productive inclusion (Singer, 2018; Morais; Costa, 2021).
Territorial development	Integration between social policies and the local economy.	Reduction of social vulnerabilities and strengthening of the local economy.	Territorial development as a multidimensional process (Dallabrida, 2020).

Source: Elaboration by the authors based on research data (2025) and the literature.

The synthesis presented in Table 5 allows us to understand in an integrated way how income transfer policies can produce effects that go beyond the care dimension. In the case of the Gira Renda Program, the direct transfer of resources to beneficiary families contributed not only to reducing immediate social vulnerabilities, but also to stimulating the circulation of income in the territory and strengthening local economic activities.

Social policies can play an important role in boosting territorial economies, especially when associated with mechanisms that encourage consumption in local establishments. Thus, the experience analyzed in Parauapebas demonstrates that municipal income transfer programs can contribute to broader strategies of territorial development, particularly when articulated with productive inclusion and solidarity economy initiatives.

5 CONCLUSION

The present study aimed to analyze the social and economic impacts of the Gira Renda Program in the municipality of Parauapebas (PA), seeking to understand how this public policy contributed to territorial development processes. The analysis of the empirical data obtained through questionnaires applied to the beneficiaries and an interview with a former manager of the program allowed us to identify relevant results both in the social sphere and in the local economic dynamics.

The results indicate that the program played an important role in reducing immediate social vulnerabilities. The cash transfer contributed to expanding access to essential goods and reducing social vulnerabilities among beneficiary families. These findings reinforce evidence present in the literature on income transfer policies, which highlight their importance as instruments of social protection and poverty reduction. In addition to the direct social effects, the study identified indirect impacts on the local economy. The use of the benefit in commercial establishments registered in the municipality stimulated local consumption and contributed to boosting small businesses.

However, the results also show important limitations. The low value of the benefit and the absence of complementary policies for productive inclusion restricted the potential for structural transformation of the program. The literature indicates that these programs have a greater impact when articulated with policies of productive inclusion and solidarity economy.

Thus, it is concluded that the Gira Renda Program contributed to reduce social vulnerabilities and stimulate the local economy in the municipality of Parauapebas. However, its potential to promote more lasting transformations depends on integration with broader public policies of productive inclusion and territorial development. Future research may

deepen the analysis of municipal cash transfer programs in Amazonian contexts.

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PERCEPTION OF SCIENTIFIC AND TRANSVERSAL COMPETENCIES IN NURSING STUDENTS: A COMPARATIVE ANALYSIS BETWEEN UNIVERSITY COHORTS

PERCEPÇÃO DAS COMPETÊNCIAS CIENTÍFICAS E TRANSVERSAIS EM ESTUDANTES DE ENFERMAGEM: ANÁLISE COMPARATIVA ENTRE COORTES UNIVERSITÁRIAS

PERCEPCIÓN DE LAS COMPETENCIAS CIENTÍFICAS Y TRANSVERSALES EN ESTUDIANTES DE ENFERMERÍA: ANÁLISIS COMPARATIVO ENTRE COHORTES UNIVERSITARIOS



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ABSTRACT

In higher education in health sciences, the development of scientific and transversal competencies is essential for training professionals capable of critically analyzing evidence and applying it in clinical practice. The aim of the study was to compare the perception of scientific and transversal competencies among nursing students between the periods 2019 and 2025, in order to identify possible differences associated with the educational contexts in which their training took place. Materials and Methods: A quantitative, non-experimental, cross-sectional, and comparative study was conducted among undergraduate nursing students at a public university in Nayarit, Mexico. The sample consisted of 331 students

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selected through non-probabilistic convenience sampling. Data were collected using a questionnaire based on an ad hoc instrument and analyzed using descriptive and inferential statistics, employing χ^2 and Mann-Whitney U tests ($p < 0.05$). Results: The findings showed that transversal competencies were mainly at intermediate levels of development, highlighting teamwork and ethical and social commitment. In contrast, scientific competencies showed lower levels of perceived mastery, particularly in methodological skills. Conclusions: The findings highlight the need to strengthen research training and to promote pedagogical strategies aimed at critical thinking and scientific literacy among nursing students.

Keywords: Scientific Competencies. Transversal Competencies. Nursing Students. Higher Education. Perception of Competencies.

RESUMO

Na educação superior em ciências da saúde, o desenvolvimento de competências científicas e transversais é fundamental para a formação de profissionais capazes de analisar criticamente as evidências e aplicá-las na prática clínica. O objetivo do estudo foi comparar a percepção das competências científicas e transversais em estudantes de enfermagem entre os períodos de 2019 e 2025, com o intuito de identificar possíveis diferenças associadas aos contextos educacionais nos quais sua formação ocorreu. Materiais e Métodos: Foi realizado um estudo quantitativo, não experimental, transversal e comparativo com estudantes do curso de graduação em Enfermagem de uma universidade pública de Nayarit, México. A amostra foi composta por 331 estudantes selecionados por meio de amostragem não probabilística por conveniência. Os dados foram coletados por meio de um questionário baseado em um instrumento ad hoc e analisados por meio de estatística descritiva e inferencial, utilizando os testes χ^2 e U de Mann-Whitney ($p < 0,05$). Resultados: Os resultados mostraram que as competências transversais situaram-se predominantemente em níveis intermediários de desenvolvimento, com destaque para o trabalho em equipe e o compromisso ético e social. Em contraste, as competências científicas apresentaram níveis mais baixos de percepção de domínio, particularmente nas habilidades metodológicas. Conclusões: Os achados ressaltam a necessidade de fortalecer a formação em pesquisa e promover estratégias pedagógicas voltadas ao pensamento crítico e à alfabetização científica entre estudantes de enfermagem.

Palavras-chave: Competências Científicas. Competências Transversais. Estudantes de Enfermagem. Educação Superior. Percepção de Competências.

RESUMEN

En la educación superior en ciencias de la salud, el desarrollo de competencias científicas y transversales es fundamental para la formación de profesionales capaces de analizar críticamente la evidencia y aplicarla en la práctica clínica. El objetivo del estudio fue comparar la percepción de las competencias científicas y transversales en estudiantes de enfermería entre los periodos 2019 y 2025, con el fin de identificar posibles diferencias asociadas a los contextos educativos en los que se desarrolló su formación. Materiales y métodos: Se realizó un estudio cuantitativo, no experimental, transversal y comparativo en estudiantes de la Licenciatura en Enfermería de una universidad pública de Nayarit, México. La muestra estuvo integrada por 331 estudiantes seleccionados mediante muestreo no probabilístico por conveniencia. La información se recolectó mediante un cuestionario basado en un instrumento ad hoc y se analizó mediante estadística descriptiva e inferencial, utilizando pruebas χ^2 y U de Mann-Whitney ($p < 0.05$). Los resultados mostraron que las competencias

transversales se ubicaron principalmente en niveles intermedios de desarrollo, destacando el trabajo en equipo y el compromiso ético y social. En contraste, las competencias científicas presentaron menores niveles de percepción de dominio, particularmente en habilidades metodológicas. Conclusiones: Los hallazgos resaltan la necesidad de fortalecer la formación investigativa y promover estrategias pedagógicas orientadas al pensamiento crítico y la alfabetización científica en estudiantes de enfermería.

Palabras clave: Competencias Científicas. Competencias Transversales. Estudiantes de Enfermería. Educación Superior. Percepción de Competencias.

1 INTRODUCTION

In recent decades, higher education systems have progressively transitioned towards training models focused on the development of skills. This change seeks to strengthen the comprehensive training of students and respond to the social, scientific and professional demands of contemporary society. From this perspective, current pedagogical proposals promote the integration of knowledge, skills, and attitudes that allow students to function in complex and constantly changing contexts. (Covarrubias Apablaza et al., 2022; Saravia Domínguez et al., 2024)

Competency-based education is based on the need for training processes to transcend the transmission of theoretical content and promote the development of skills that allow students to apply knowledge in real situations. In this approach, competencies are understood as the integrated mobilization of conceptual, procedural and attitudinal knowledge that allows responding in a pertinent way to diverse academic and professional situations (Covarrubias Apablaza et al., 2022). This educational model has been widely adopted in higher education, particularly in areas related to health sciences, where the complexity of health problems requires professionals with analytical skills, critical thinking and informed decision-making capacity.

In the field of health sciences, competency-based education has acquired increasing relevance, favoring the training of professionals capable of analyzing scientific information, addressing clinical problems and supporting their decisions on available evidence. In the case of nursing, the development of scientific competencies is a fundamental element, since it contributes to the strengthening of critical thinking, the consolidation of evidence-based practice and the improvement of the quality of care provided to patients. (Machado et al., 2024) (Saravia Domínguez et al., 2024)

Scientific competencies include methodological knowledge, analytical skills, and attitudes aimed at understanding, producing, and applying scientific knowledge in health care contexts. Among these skills are the systematic search of scientific literature, the critical evaluation of information, the understanding of different methodological designs and the use of basic statistical tools to interpret research results. Its development favors the training of reflective professionals, capable of assessing the available evidence and contributing to the continuous improvement of health systems. (Karazhigitova et al., 2024) (de Oliveira Bernardino et al., 2023)

From a training perspective, the development of scientific competencies in nursing students is closely related to the incorporation of scientific literacy processes. This concept refers to the ability to understand phenomena related to science, interpret evidence-based

information and participate in an informed way in decision-making related to health and social well-being (Cuevas Romo et al., 2016). In the context of university education, scientific literacy helps future professionals to develop a critical stance towards the available information and strengthen their ability to integrate scientific knowledge into clinical practice.

In a complementary way, contemporary educational models have incorporated the development of transversal competences. These refer to general skills that allow students to perform effectively in different academic, professional and social contexts. They include skills related to critical thinking, academic communication, knowledge management, collaborative work and self-regulation of learning. The integration of scientific and transversal competencies favors a more complete professional training, by articulating technical skills with cognitive, social and ethical capacities necessary for the exercise of the profession. (Loura et al., 2020)

Various international organizations have pointed out that competencies imply the integrated mobilization of knowledge, skills, and attitudes to respond to individual and social demands in specific contexts. The Organization for Economic Cooperation and Development (OECD) has stressed that its development is a central element in training citizens capable of facing the challenges of the knowledge society. In this sense, the integration of scientific and transversal skills favors a more complete professional training, by articulating technical skills with cognitive, social and ethical capacities necessary for the exercise of the profession. (OECD, 2025)

In nursing education, the scientific dimension is incorporated transversally into the curricula with the purpose of strengthening the students' ability to understand health-related phenomena, interpret research results and apply scientific evidence in professional practice. However, the development of these competencies does not depend solely on the formal curriculum. Factors associated with the educational context, pedagogical strategies, opportunities for participation in research activities and the institutional conditions in which the training process takes place also intervene. (Arévalo-Ipanaqué et al., 2023)

Evidence indicates that student participation in research projects and scientific dissemination activities contributes significantly to the strengthening of scientific competencies and critical thinking. However, in many nursing programs, participation in these types of experiences remains limited, which may influence how students perceive their own development in the scientific field. (Quiñones Gurrola et al., 2025) (Cuba Sancho & Vivas, 2016)

In the context of higher education in the area of health sciences, some studies have analyzed the perception that students have about the development of their scientific

competencies. At a public university in Nayarit, and collaborators conducted research with 388 students from health programs using an instrument composed of 69 items distributed in six sections aimed at characterizing scientific competence. The results showed that, although students recognize the importance of scientific skills for their professional training, there are still areas of opportunity related to the application of the scientific method, the use of technological tools for research, and the mastery of methodological aspects such as research designs and sampling techniques. These findings suggest the need to strengthen pedagogical strategies aimed at promoting the development of scientific competencies and student participation in research activities during university education. (Ruiz Bernés et al., 2019)

Starting in 2020, the COVID-19 pandemic generated important transformations in the academic organization of higher education institutions, including the adoption of virtual or hybrid teaching modalities and adjustments in clinical practices. These conditions gave rise to cohorts that studied under different educational contexts, which could have influenced the way they perceive the development of their scientific and transversal competencies. (OECD, 2025)

In the context of public universities in the state of Nayarit, Mexico, empirical evidence on this topic is still limited, particularly in comparative studies between cohorts formed in different academic periods. Therefore, the present study aims to compare the perception of scientific and transversal competencies in nursing students between the periods 2019 and 2025, in order to identify possible differences associated with the educational contexts in which their training was developed.

2 MATERIALS AND METHODS

Study design: A quantitative, non-experimental, cross-sectional and comparative study was carried out, aimed at analyzing the differences in the perception of scientific and transversal competencies in nursing students belonging to two temporary cohorts corresponding to the academic periods 2019 and 2025.

Population and sample: The population was made up of students enrolled in the Bachelor's Degree in Nursing at a public university in the state of Nayarit, Mexico. Enrollment was 1,046 students in 2019 and 953 in 2025 (N = 1,999). The sample was obtained through non-probabilistic convenience sampling and was made up of 331 students: 192 from the 2019 period (76.6% women) and 139 from the 2025 period (56.1% women). (Hernández Sampieri & Mendoza Torres, 2018)

Variables: The independent variable was the academic period (2019 and 2025) and the dependent variable was the perception of academic competencies, made up of scientific competencies and transversal competencies. Sociodemographic variables such as sex were also considered. Transversal competencies included analytical and synthesis skills, time planning, second-language communication, criticism and self-criticism, creativity, teamwork, interdisciplinary work, and social ethical engagement.

Instruments: The information was collected through a structured questionnaire based on the ad hoc instrument to assess the perception of scientific competencies in university students. The instrument included 47 items distributed in seven sections: sociodemographic data, transversal competencies linked to scientific activity, use of information technologies in research, generation of scientific knowledge, experiences of scientific dissemination, knowledge of data analysis software and perception of the influence of the academic program on the development of scientific competencies. Dichotomous questions (yes/no) and some open-ended questions predominated. (Ruiz Bernés et al., 2019)

Procedure: Data collection was carried out through an online questionnaire developed in Google Forms, distributed to nursing students during the corresponding academic periods. Participation was voluntary and anonymous. Participants were previously informed about the objectives of the study and agreed to participate through informed consent.

Statistical analysis: Descriptive and inferential statistics were applied. Frequencies and percentages were calculated to describe the sample. To compare the 2019 and 2025 cohorts, the chi-square test (χ^2) in categorical variables and the Mann-Whitney U test were used to analyze differences in the perception of competencies. A significance level of $p < 0.05$ was considered.

Ethical considerations: The study was conducted in accordance with the **Declaration of Helsinki** and the **General Health Law on Health Research in Mexico**. It was classified as **risk-free research**, as it only involves the application of surveys or questionnaires where the subjects are not identified or sensitive aspects of the behavior are discussed. Voluntary participation, anonymity and confidentiality of information were guaranteed. (World Medical Association, 2024; Regulations of the General Health Law on Health Research, 2014)

3 RESULTS AND DISCUSSION

Table 1 characterizes the participation of 331 students of the Bachelor's Degree in Nursing, of which 192 (58.0%) corresponded to the 2019 academic period and 139 (42.0%) to the 2025 period. In the total sample, the female sex predominated with 225 participants

(68.0%), while 106 (32.0%) were men. When comparing both periods, differences were observed in the distribution by sex, with a higher proportion of women in 2019 and a relative increase in male participation in 2025. This behavior is consistent with the trend observed in nursing training programs, where female enrollment has historically predominated, although in recent years a progressive increase in male participation in this discipline has been reported (Sharma & Begum, 2023).

Table 1

Characterization of the participants

Variables	2019	2025	Total
	f, %	f, %	f, %
Gender			
Female	147, 63.3	78, 34.7	225, 100.0
Male	45, 42.5	61, 57.5	106, 100.0
Total	192, 58.0	139, 42.0	331, 100.0

Table 2 shows that the perception of transversal competencies showed that, in both periods, the predominant category was "has the notion", which suggests an intermediate level of development of these skills among students. This result coincides with studies that indicate that many transversal competencies in higher education are developed gradually and, sometimes, implicitly within the academic curriculum (Albarrán Villalba, 2018; Magnoler, 2018).

Table 2

Perception and skill of the transversal competence of nursing students by response period

Perception and Skill of Transversal Competence – 2019	Acquired f, %	He has the notion f, %	Not Acquired f, %
Analyze and synthesize	22, 11.5	155, 80.7	15, 7.8
Plan your time	57, 29.7	112, 58.3	23, 12.0
Time Management	75, 39.1	108, 56.3	9, 4.7
Comprehension of texts in the second language	6, 3.1	50, 26.0	136, 70.8
Communicate in writing in a second language	6, 3.1	38, 19.8	148, 77.1
Communicate orally in a second language	7, 3.6	48, 25.0	137, 71.4
Criticism and self-criticism	45, 23.4	133, 69.3	14, 7.3
Act creatively	96, 50.0	90, 46.9	6, 3.1
Work as a team	121, 63.0	69, 35.9	2, 1.0
Working in interdisciplinary contexts	9, 4.7	59, 30.7	124, 64.6
Ethical and social commitment	115, 59.9	74, 38.5	3, 1.6
Perception and Skill of Transversal Competence – 2025			
Analyze and synthesize	3, 2.2	111, 79.9	25, 18.0
Plan your time	23, 16.5	78, 56.1	38, 27.3
Time Management	28, 20.1	93, 66.9	18, 12.9

Comprehension of texts in the second language	2, 1.4	38, 27.3	99, 71.2
Communicate in writing in a second language	1, 0.7	36, 25.9	102, 73.4
Communicate orally in a second language	1, 0.7	50, 36.0	88, 63.3
Criticism and self-criticism	9, 6.5	98, 70.5	32, 23.0
Act creatively	37, 26.6	96, 69.1	6, 4.3
Work as a team	100, 71.9	39, 28.1	0, 0.0
Working in interdisciplinary contexts	8, 5.8	68, 48.9	63, 45.3
Ethical and social commitment	42, 30.2	89, 64.0	8, 5.8

In particular, cognitive competencies such as analyzing and synthesizing information showed a decrease in the proportion of students who reported having acquired this skill in 2025 compared to 2019. A similar trend was observed in the ability to plan and manage time, where the proportion of students who indicated that they had not fully developed this competence increased.

These variations could be related to changes in learning processes in increasingly digitized educational contexts. Various authors have pointed out that, although access to information has been significantly expanded with the use of digital technologies, this does not necessarily translate into the strengthening of critical thinking or complex cognitive skills if it is not accompanied by pedagogical strategies aimed at reflection and in-depth analysis of information. (González Ttito et al., 2025; Karipbayeva et al., 2023)

On the other hand, competencies related to the mastery of a second language presented the lowest levels of perception of proficiency in both periods analyzed. Most of the students reported not having acquired sufficient skills for written comprehension and communication in a foreign language. This result coincides with research that has indicated that the mastery of scientific English continues to be one of the main limitations for access to international academic literature in health sciences students in Latin America (Marcillo-García Concepción Elizabeth et al., 2024; Salamonson et al., 2008) .

In contrast, interpersonal competencies, particularly teamwork and ethical and social commitment, presented the highest levels of mastery perception. The ability to work in a team showed high percentages in both periods, which is consistent with the training approach of nursing, a discipline that promotes collaborative work and social responsibility within professional practice (Wu, 2025) .

The comparative analysis between the periods showed variations in some transversal competencies, with decreases in skills related to time management, creativity and critical capacity, while competencies related to collaborative and interdisciplinary work showed trends of improvement (See Table 3).

Table 3

Percentage comparison ($\Delta\%$) of the perception and ability of transversal competences between 2019 and 2025

Transversal competence	Percentage comparison ($\Delta\%$)		
	Acquired	He has the notion	Not Acquired
Analyze and synthesize	-9.3	-0.8	10.2
Plan your time	-13.2	-2.2	15.3
Time Management	-19.0	10.6	8.2
Comprehension of texts in the second language	-1.7	1.3	0.4
Communicate in writing in a second language	-2.4	6.1	-3.7
Communicate orally in a second language	-2.9	11	-8.1
Criticism and self-criticism	-16.9	1.2	15.7
Act creatively	-23.4	22.2	1.2
Work as a team	8.9	-7.8	-1.0
Working in interdisciplinary contexts	1.1	18.2	-19.3
Ethical and social commitment	4.1	-8.3	4.2

Inferential analysis using the Mann-Whitney U test confirmed statistically significant differences between periods in several cross-cutting competencies, particularly in analyzing and synthesizing information, planning and managing time, criticism and self-criticism, creativity, interdisciplinary work, and ethical and social engagement ($p < 0.05$). These results suggest that the perception of the development of certain competencies may be influenced by factors associated with the educational context and the training experiences of each cohort (See Table 4).

Table 4

Comparison of the perception and skill of the transversal competence of nursing students between response periods

Perception and skill of transversal competence	Female	Male	Total
Analyze and synthesize	4788.0**	1157.0*	10998.0**
Plan your time	4849.5*	940.5**	10359.5**
Time Management	4783.0*	1003.5**	10266.0**
Comprehension of texts in the second language	5544.0	1162.0	13228.0
Communicate in writing in a second language	5454.5	1193.0	12939.0
Communicate orally in a second language	5037.0*	1174.5	12421.5
Criticism and self-criticism	4473.0**	967.5**	9638.5**
Act creatively	4810.0*	963.0**	10242.0**
Work as a team	5233.0	1159.5	12114.5
Working in interdisciplinary contexts	4542.0*	1258.0	10844.0**
Ethical and social commitment	3985.5**	1060.5*	9221.0**

* $p < 0.05$ and ** $p < 0.01$ with Mann-Whitney U.

In relation to scientific competencies linked to the generation and application of knowledge, the results showed a predominance of the "not acquired" category in both periods analyzed, which suggests limitations in the development of research skills among students.

This behavior is consistent with what was reported in a previous study carried out at the same institution by those who evaluated the perception of scientific competencies in students in the area of health sciences using an instrument of 69 items applied to 388 participants. In this study, limitations in skills related to the application of research designs, sampling techniques, and the use of methodological tools were also identified, which suggests that the strengthening of research training continues to represent a challenge within academic programs in the health area (See Table 5). Bernés et al. (2019)

Table 5

Perception for the generation and dissemination of scientific knowledge in nursing students by response period

Generation and dissemination of knowledge – 2019	Acquired	Not Acquired
	f, %	f, %
Knows how to apply experimental designs	67, 34.9	125, 65.1
Knows how to apply non-experimental designs	56, 29.2	136, 70.8
Knows how to apply sample selection techniques	33, 17.2	159, 82.8
Considers statistical methods for data analysis to be important	119, 62	73, 38
Generation and dissemination of knowledge - 2025		
Knows how to apply experimental designs	47, 33.8	92, 66.2
Knows how to apply non-experimental designs	33, 23.7	106, 76.3
Knows how to apply sample selection techniques	7, 5.0	132, 95.0
Considers statistical methods for data analysis to be important	39, 28.1	100, 71.9

Table 6 shows that in particular, low levels of mastery perception were identified in aspects such as knowledge of sample selection techniques and the assessment of statistical methods for data analysis. Likewise, a decrease was observed in the proportion of students who recognized the importance of statistics for the analysis of scientific information in the most recent period.

These findings coincide with research that indicates that, in many health sciences training programs, research teaching tends to concentrate on isolated theoretical subjects, without sufficient integration with practical research experiences, which limits the development of scientific competencies in students (Koritzinsky et al., 2017; Wu, 2025).

Similarly, the study identified that a significant proportion of students reported not having fully developed skills related to the application of experimental and non-experimental designs, as well as the use of sample selection techniques. These findings reinforce the idea that, although the curricula include content related to research methodology, the effective development of these competencies requires training experiences more linked to research practice and the active participation of students in scientific projects. Bernés et al. (2019)

The comparative analysis between cohorts showed statistically significant differences in some scientific competencies, particularly in the knowledge of sampling techniques and in the assessment of statistical methods, while the differences observed in the application of experimental and non-experimental designs did not reach statistical significance.

Table 6

Percentage comparison ($\Delta\%$) between periods of perception for the generation and dissemination of scientific knowledge

Competition	Percentage comparison ($\Delta\%$)	
	Acquired	Not Acquired
Knows how to apply experimental designs	-1.1	1.1
Knows how to apply non-experimental designs	-5.5	5.5
Knows how to apply sample selection techniques	-12.2	12.2
Considers statistical methods for data analysis to be important	-33.9	33.9

The comparative analysis by sex (Table 7) showed differences in the perception of some scientific competencies. In general, women reported higher levels of mastery in research-related skills, particularly in the application of experimental designs, non-experimental designs, and assessment of statistical methods, where statistically significant differences were identified using the Mann-Whitney U test ($p < 0.01$).

Table 7

Comparison of the generation and dissemination of knowledge of the transversal competence of nursing students between response periods

Generation and dissemination of knowledge	Female	Male	Total
Knows how to apply experimental designs	5374.5	1260.5	13199.5**
Knows how to apply non-experimental designs	5487.0	1299.0	12620.0**
Knows how to apply sample selection techniques	5008.5*	1265.0	11722.5
Considers statistical methods for data analysis to be important	3918.0**	809.5**	8817.5

* $p < 0.05$ and ** $p < 0.01$ with Mann-Whitney U.

Some studies have suggested that health sciences students tend to be more involved in academic activities related to critical analysis and research, which could be associated with high levels of academic engagement and thought-oriented learning styles (Bovijn et al., 2017).

In this sense, studies carried out on health sciences students have indicated that the strengthening of scientific competence requires not only the teaching of methodological content, but also the integration of technological tools, innovative didactic strategies and the participation of interdisciplinary research groups that favor situated learning and the

development of scientific thinking. These recommendations have also been pointed out in previous research carried out in the same student population, where the need to strengthen research training through the incorporation of new pedagogical strategies within the university curriculum is raised (Ruiz Bernés et al., 2019).

Overall, the results of this study suggest that, although nursing education favors the development of interpersonal and ethical competencies, there are still areas of opportunity in the strengthening of scientific and critical thinking competencies. In this sense, several authors have pointed out the need to integrate pedagogical strategies that promote the active participation of students in research processes, such as problem-based learning, training projects and early research experiences within the university curriculum (Bovijn et al., 2017; González Ttito et al., 2025; Wu, 2025).

4 CONCLUSIONS

The study made it possible to compare the perception of the development of scientific and transversal competencies in nursing students between the 2019 and 2025 cohorts, identifying differences associated with the educational contexts in which their training was developed. In general, transversal competencies were located at intermediate levels of development, with the category "has the notion" predominating. Skills related to teamwork and ethical and social commitment were perceived as the most strengthened, which is consistent with the nursing's training approach.

In contrast, scientific competencies presented more limited levels of perception of mastery, particularly in methodological skills related to the research process, such as knowledge of sampling techniques and the evaluation of statistical methods. The differences observed between cohorts suggest that the educational context can influence the perception of the development of these competencies, which highlights the need to strengthen research training and promote pedagogical strategies aimed at the development of critical thinking and scientific literacy.

5 FINAL CONSIDERATIONS

The study has some limitations. The use of non-probability sampling for convenience and the application of self-reporting instruments may limit the generalizability of results and be subject to perception biases. Likewise, the cross-sectional comparative design between cohorts allows us to identify differences between periods, but not to establish causal relationships. In addition, since it is carried out in a single institution, the findings must be interpreted within that educational context.

The results show the need to strengthen training in scientific and transversal competencies in nursing programs through pedagogical strategies that promote critical thinking and scientific literacy. Future research could use longitudinal designs or multicenter studies that allow for a more in-depth analysis of the educational factors associated with the development of these competencies.

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BOARD OF DIRECTORS AND PROJECT PORTFOLIO GOVERNANCE: A THEMATIC ANALYSIS BRIDGING CORPORATE OVERSIGHT AND STRATEGIC EXECUTION

CONSELHO DE ADMINISTRAÇÃO E GOVERNANÇA DE PORTFÓLIO DE PROJETOS: UMA ANÁLISE TEMÁTICA CONECTANDO A SUPERVISÃO CORPORATIVA E A EXECUÇÃO ESTRATÉGICA

CONSEJO DE ADMINISTRACIÓN Y GOBERNANZA DEL PORTAFOLIO DE PROYECTOS: UN ANÁLISIS TEMÁTICO QUE VINCULA LA SUPERVISIÓN CORPORATIVA Y LA EJECUCIÓN ESTRATÉGICA



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ABSTRACT

This article examines the roles and responsibilities of Boards of Directors in relation to project portfolio governance. We discuss how the characteristics of the Board, including its composition, independence, diversity, and expertise, affect a range of project portfolio governance objectives, including organizational performance, sustainability, and risk. We present a wide range of literature on the nature of Boards and the challenges of effective project portfolio governance. We use thematic analysis to organize and highlight the main themes from the literature. We demonstrate how the Board acts as a 'bridge' between corporate governance and project portfolio management. The paper's findings highlight the Board's role in implementing and executing the corporate strategy, managing risk and innovation, and ensuring accountability. Finally, we discuss the theoretical, practical, and policy implications of the findings from an integrated perspective of governance and effective strategic execution.

Keywords: Corporate Governance. Board of Directors. Project Portfolio Governance. Thematic Analysis. Strategic Execution.

RESUMO

Este artigo examina os papéis e responsabilidades dos Conselhos de Administração em relação à governança de portfólio de projetos. Discutimos como as características do Conselho, incluindo sua composição, independência, diversidade e expertise, afetam uma série de objetivos da governança de portfólio de projetos, incluindo desempenho organizacional, sustentabilidade e risco. Apresentamos uma ampla gama de literatura sobre a natureza dos Conselhos e os desafios da governança eficaz de portfólio de projetos. Utilizamos a análise temática para organizar e destacar os principais temas da literatura.

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Demonstramos como o Conselho atua como uma “ponte” entre a governança corporativa e a gestão de portfólio de projetos. Os achados do artigo destacam o papel do Conselho na implementação e execução da estratégia corporativa, na gestão de riscos e inovação, e na garantia da accountability. Por fim, discutimos as implicações teóricas, práticas e de políticas dos resultados a partir de uma perspectiva integrada de governança e execução estratégica eficaz.

Palavras-chave: Governança Corporativa. Conselho de Administração. Governança de Portfólio de Projetos. Análise Temática. Execução Estratégica.

RESUMEN

Este artículo examina los roles y responsabilidades de los Consejos de Administración en relación con la gobernanza del portafolio de proyectos. Discutimos cómo las características del Consejo, incluyendo su composición, independencia, diversidad y experiencia, afectan una serie de objetivos de la gobernanza del portafolio de proyectos, tales como el desempeño organizacional, la sostenibilidad y el riesgo. Presentamos una amplia gama de literatura sobre la naturaleza de los Consejos y los desafíos de una gobernanza eficaz del portafolio de proyectos. Utilizamos el análisis temático para organizar y resaltar los principales temas de la literatura. Demostramos cómo el Consejo actúa como un “puente” entre la gobernanza corporativa y la gestión del portafolio de proyectos. Los hallazgos del artículo destacan el papel del Consejo en la implementación y ejecución de la estrategia corporativa, la gestión del riesgo y la innovación, y la garantía de la rendición de cuentas. Finalmente, discutimos las implicaciones teóricas, prácticas y de políticas de los resultados desde una perspectiva integrada de gobernanza y ejecución estratégica eficaz.

Palabras clave: Gobernanza Corporativa. Consejo de Administración. Gobernanza del Portafolio de Proyectos. Análisis Temático. Ejecución Estratégica.

1 INTRODUCTION

Corporate governance is an important area of study in management research because it affects a corporation's legitimacy, accountability, and strategic management. Corporate governance includes systems, policies, laws, institutions, and processes employed by companies to govern and regulate management. Practically speaking, it is found embodied in the board of directors, which serves a monitoring function and/or as a strategic management team (Useem, 2010; Yermack, 1996). Yet much of the research has focused on large, publicly traded corporations listed on major exchanges. The number of smaller, privately held or owner-managed firms, which are critical to local economies, receives scant attention.

This special issue is dedicated to filling this void by examining governance practices, boards of directors, and owner-manager relations in the privately owned/managed transnational firm. We are looking for original research – qualitative and/or quantitative, or any method in between – conducted in any region of the world. We are particularly interested in research that integrates frameworks such as corporate governance with other theories, including institutional theory (Gompers et al., 2003) and stakeholder theory (Zahra & Pearce, 1989), and we encourage the use of comparative designs and/or large datasets.

The way scholars study the roles and responsibilities of boards of directors has evolved substantially in the last two decades. Initially, the board's monitoring of the firm's financial performance was the sole area of focus. However, in recent years, a growing body of research has examined the roles of boards with respect to board diversity, environmental and social sustainability, organizational innovation, and risk-taking (Bear et al. 2010; Bernile et al. 2018; García-Sánchez et al. 2021). This additional focus is a response to social and institutional pressures, stakeholders' expectations, legislation, and the dissemination of the ESG (environmental, social, governance) agenda by global investors (Konadu et al. 2022; Ortiz-de-Mandojana & Bansal 2016). While strategic implementation and portfolio governance present distinct challenges for the Board, project portfolios are a special case that needs particular attention. In this case, the Board must ensure that the overall project portfolios are strategically aligned, take optimal risks, and create long-term value. To discharge this responsibility, the Board needs to understand how the governance system, including the leadership system and decision-making processes, works. Additionally, the Board must have insight into how key stakeholders can impact strategic implementation and influence specific project portfolios.

There has been a rapid increase in research focusing on board diversity in recent years. Studies have found that boards with women (gender diversity) and boards comprising

directors from diverse demographic backgrounds (demographic diversity) can create beneficial outcomes at the firm level, such as better decision-making, increased innovation, and enhanced corporate social responsibility (Byron & Post, 2016; Joecks et al., 2013; Post & Byron, 2015). However, other studies have identified the phenomenon of tokenism and, as a result, have highlighted the need for a 'sufficient' or 'critical mass' of gender and demographic diversity on boards to achieve tangible benefits. While independent boards can help mitigate agency problems and improve disclosure quality, there are also strong arguments for increased organizational transparency independent of board composition. While recent studies have found that independent directors serve to protect a variety of stakeholders' interests (Chau & Gray 2010; Donnelly & Mulcahy 2013; Rupley et al. 2012), effective independent directors are shaped by a number of internal and external factors, including dominant owners, institutional investors, and the business environment (Sánchez & Martínez-Ferrero 2019).

Sustainability and environmental governance are relevant issues for boards of directors. As environmental, social, and governance (ESG) considerations are increasingly incorporated into the strategic decisions of the general meeting, Boards of Directors are challenged to assume this new role and balance short-term performance with long-term value creation while accounting for ESG factors. Sustainability is nowadays a fundamental aspect of corporate social responsibility (Ben-Amar et al., 2017; Fernández-Gago et al., 2018; García-Sánchez et al., 2023; Crecente et al., 2021; Ghisetti et al., 2021). Using thematic analysis as our methodological approach to synthesize findings from qualitative and quantitative studies, we explore what the existing literature tells us about boards' work in this section. The method's thematic approach allows for a comprehensive analysis of literature across studies and types. The topics in the corporate governance literature are diverse in terms of methodologies and findings. The article has three aims. The first aim is to review and synthesize past research on corporate governance and the boards of directors' roles in project portfolio governance. The second aim is to identify major recurring themes found in current corporate governance research, including diversity and sustainability, power distribution among top management team members, and methodological advancements. The third aim is to draw implications for theory, practice, and policy, and to discuss how boards can perform the strategic governance role and put the strategy into practice by managing project portfolios to achieve profitability, sustainability, and resilience while increasing organizational legitimacy.

2 BACKGROUND

2.1 THEORETICAL FOUNDATIONS OF CORPORATE GOVERNANCE

Corporate governance is a system of rules, practices, and processes by which a company is controlled and run. Corporate governance assurance implies accountability, transparency, and responsibility to stakeholders; it thus becomes crucial for enabling effective supervision and strategy formulation by the Board of Directors (Gompers et al., 2003; Zahra & Pearce, 1989). Specifically, in what manner does the Board pursue these ends? Governance theories have undergone a gradual evolution over the years. Agency theory views the role of boards particularly with reference to monitoring the relationship and conflicts of interest between managers and shareholders (Jaggi, Paul, & Sugaman, 2009). The alternative perspective of stewardship theory views managers more as responsible stewards of organizational resources and focuses on trust and cooperation (Singh, 2007). Resource dependence theory views boards in terms of their role in obtaining critical resources and legitimacy (Ricart, Tena, & Enrique, 2005). Institutional theory takes a societal perspective and is concerned with governance from a legal perspective, ensuring that governance practices align with prevailing social and institutional norms and expectations (Ortiz-de-Mandojana & Bansal, 2016). The upper echelons perspective explores how the upper levels of organizations, such as CEOs and top executives or their Boards of Directors, influence performance. It focuses on the cognitive frames and values this decision makers bring to the organization (Carpenter et al., 2004; Hambrick, 2007). Regarding project portfolio governance, studies have examined the impact of board composition, diversity, and expertise on strategic decisions (e.g., Ferzoco et al., 2010). Recent research explores cognitive distortions in managers' decision-making processes. It takes an integrative view that encompasses both rational and behavioral perspectives (Abatecola et al., 2018).

2.2 BOARD COMPOSITION AND DIVERSITY

The composition of the Boards matters. Research demonstrates that gender, ethnic, and industry experience diversity are all associated with better firm performance, more creativity, and a greater emphasis on corporate social responsibility (Byron & Post, 2016; Joecks et al., 2013; Post & Byron, 2015). While the link to sustainability is less consistent (Bear et al., 2010), there is evidence that more diverse Boards are more engaged in sustainability efforts (Konadu et al., 2022) and adhere to best practices of corporate governance. Even as steps are being taken towards greater diversity on boards, new challenges are emerging. One of these challenges concerns the risk of tokenism inherent in many current diversity initiatives. While symbolic diversity may initially become prevalent, it

is eventually necessary to build a critical mass of diverse directors (Torchia et al., 2011). Further, the meaningfulness of diversity is contingent upon a variety of contextual factors and institutions (Rashid, 2018). Finally, in some contexts, ownership concentration may also stifle diversity (Sánchez & Martínez-Ferrero, 2019).

2.3 BOARD INDEPENDENCE AND ACCOUNTABILITY

To protect various stakeholders and promote greater transparency within businesses, an independent director is generally viewed as a positive force in corporate governance. Such directors are better able to police top management, reduce the likelihood of employee earnings management, and create higher-quality disclosure (Chau & Gray, 2010; Donnelly & Mulcahy, 2013; Rupley et al., 2012). The influence of independence on audit shakeout outcomes, however, is constrained. The influence of independence on audit shakeout outcomes is contingent upon firm- and market-specific factors, including ownership structure, institutional environment, and cultural contexts (Nguyen & Nielsen, 2010; Ntim, 2015). In emerging, transitional, and developing economies, independent audit committees face formidable challenges posed by dominant shareholders' ownership, entrenched business groups, institutional weakness, and a lack of transparency (Orazalin & Mahmood, 2018).

2.4 SUSTAINABILITY AND ENVIRONMENTAL GOVERNANCE

Sustainability has become one of the board of directors' many responsibilities. Ben-Amar et al. (2017), Fernández-Gago et al. (2018), and García-Sánchez et al. (2023) find that boards of directors must incorporate environmental, social, and governance (ESG) considerations in their strategic decisions. Sustainability is today an integral part of business, and a company's long-term sustainability depends on effective management of environmental, social, and corporate governance issues. Climate change has become a strategic risk that businesses must manage (Crecente et al., 2021; Ghisetti et al., 2021). Boards of listed companies, more diverse and independent boards, are more likely to adopt sustainability practices and disclose environmental performance (Lanis et al., 2017; Pucheta-Martínez & Gallego-Álvarez, 2019). Sustainability governance is linked to long-run firm resilience (Ortiz-de-Mandojana & Bansal, 2016) and sustained competitive advantage (Stubbs, 2019).

2.5 RISK MANAGEMENT AND STRATEGIC EXECUTION

Risk management is a key aspect of governance. When executing a project portfolio, boards need to manage risk effectively to maximize returns and ensure the portfolio is aligned with the overall organization's strategy and sustainable in the long term. Under pressure from Enterprise Risk Management (ERM) frameworks, suppliers are required to incorporate risk factors into their strategic development processes. Ultimately, boards of directors are then responsible for those strategic decisions and must strike the right balance between opportunities for sustainable and innovative growth and pure financial return (Bromiley et al., 2015; Kuckertz et al., 2020; Kurzhals et al., 2020).

3 METHODOLOGY

3.1 RATIONALE FOR THEMATIC ANALYSIS

We employed Thematic Analysis as the method for synthesizing the results of the studies because it is a flexible method that enables synthesis across different methodologies and studies that have been undertaken using a variety of approaches from within different research traditions in the established literature on corporate governance, and the more recent literature on project portfolio governance. Although the literature varies in the theoretical perspectives that underpin it, Thematic Analysis is a methodologically robust yet interpretive research method well-suited to identifying and analyzing themes and patterns within the literature. Our study differs from a meta-analysis, which seeks to draw statistical conclusions by aggregating the results of multiple studies. Our intention was to draw theoretical conclusions and then illustrate their relevance to real-world governance problems.

3.2 DATA SOURCES AND BIBLIOMETRIC MAPPING

The analyzed corpus consists of references listed in Murillo's work, including fundamental and recent contributions on the topic. The references were analyzed using the software VOSviewer, generating bibliometric maps in the form of co-authorship networks and of keyword co-occurrence maps, as well as detailed citation profiles, which were thematically analyzed. N=119 references were investigated from Web of Science, Scopus, Google Scholar, PubMed, OpenAlex, and Semantic Scholar databases by keywords "Corporate Governance" and "Board of Directors."

3.3 CODING PROCEDURES AND ANALYTICAL FRAMEWORK

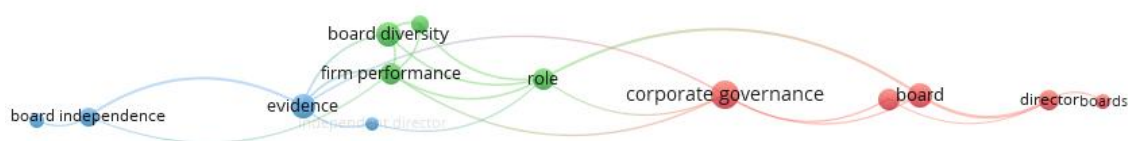
The data were coded using a well-established qualitative method. See Strauss and Corbin (1990) for coding in general, and Miles et al. (2014) for the use of systematic data displays to ensure coding quality. The researcher also adopted a reflexive stance whilst coding. Saunders, Lewis, and Thornhill (2009). This paper combines a bibliometric mapping methodology with thematic analysis to map the field of governance's scope and analyze its substance.

3.4 LIMITATIONS

The analysis contains several limitations, including the use of secondary data, some degree of interpretative subjectivity, and bibliometric limitations, such as those related to indexing biases inherent to the data source used to produce VOSviewer 1.6.20 (Eck and Waltman, 2010). However, these limitations have been addressed by using well-established methods to analyze secondary data and by complementing bibliometric methods with thematic analysis to maximize the rigor of the findings.

4 FINDINGS AND ANALYSIS

Using thematic analysis, the paper identifies five themes that explain how boards of directors affect both corporate governance and organizational legitimacy and how these, in turn, affect strategic implementation. These themes are conceptualized around the dimensions of board independence, diversity, sustainability, risk, and resilience, and the relevant theoretical perspectives. The same themes are graphically illustrated alongside the theoretical foundations in Figure 1. The same figure shows the relationships between board independence and diversity, and corporate governance and firm performance. The network representation emphasizes a complex web of theoretical foundations revolving around the construct of corporate governance, with a strong linkage among the variables of board independence, diversity, and performance. This interactive graph illustrates findings from the thematic analysis, showing how effective governance is created by a combination of structural, behavioral, and contextual factors. The obtained results have been analyzed using VosViewer (Eck and Waltman, 2010). Figure 1 shows the network map.

Figure 1*Network map*

Source: VOSviewer (version 1.6.20). Adapted from van Eck and Waltman (2010)

4.1 BOARD INDEPENDENCE

Independent boards, as advocated by the Cox Commission (Anderson & Reeb, 2004), are effective in controlling managers' propensity to exploit shareholders and in enhancing transparency and accountability. Furthermore, independent boards are found to be beneficial for firms in different markets (Boone et al., 2007; Brickley et al., 1994; Coles et al., 2008; Dalton et al., 1999; Daily et al., 2003; Fama & Jensen, 1983; Gillan, 2006; Hermalin & Weisbach, 2003; Hillman & Dalziel, 2003; Nguyen & Nielsen, 2010; Rashid, 2018; Renneboog & Szilagyi, 2011; Weisbach, 1988; Westphal, 1999; Yermack, 1996; Zahra & Pearce, 1989). On the other hand, the literature (Anderson & Reeb, 2004; Bhagat & Black, 2002; Boone et al., 2007; Brickley et al., 1994; Coles et al., 2008; Daily et al., 2003; Fama & Jensen, 1983; Jensen, 1993; Jensen & Meckling, 1976) suggests that smaller boards are more effective in making timely and expeditious decisions, which are important in today's competitive global market. In emerging markets, however, independent boards are mostly symbolic (Anderson & Reeb, 2004), a scenario that prevails due to entrenched owners and other weak, faulty institutional factors (Sharma & Hoisington, 2012).

4.2 DIVERSITY

Research frequently advances diversity, particularly gender and entrepreneurial diversity, as a catalyst for corporate social responsibility, reputation, and innovation (Adams & Ferreira, 2009; Bear et al., 2010; Byron & Post, 2015; Campbell & Mínguez-Vera, 2008; Carter et al., 2003; Dezsö & Ross, 2012; Francoeur et al., 2008; Glass & Cook, 2016; Gul et al., 2011; Hillman et al., 2007; Joecks et al., 2013; Konrad et al., 2008; Nielsen & Huse, 2010; Post & Byron, 2016; Sealy & Singh, 2010; Singh et al., 2008; Tramied & Lee, 2014; Webb et al., 2010; Terjesen et al., 2009; Torchia et al., 2011; Westphal & Milton, 2000; Zhang, 2020). However, the literature suggests that to move beyond tokenistic representation, it is important to assess the point at which diversity on boards reaches a sufficient level, or critical mass, that it begins to significantly influence board dynamics and decision-making. At this stage,

diversity becomes not just a moral obligation but a strategic advantage, fundamentally affecting how boards function and make decisions.

4.3 SUSTAINABILITY

Sustainability and ESG integration have become important for boards to adapt to be sustainable. The concept of governance has evolved from legitimacy to corporate performance through sustainable competitive advantage, with ESG disclosure and green innovation being a case in point. Hence, the two perspectives on governance of sustainability/ESG are not mutually exclusive, and boards play a critical role in institutionalizing sustainability and ESG. There is a variety of approaches to sustainability, but there is consensus that sustainability information is relevant to investors making informed investment decisions that lead to better portfolio performance. Some evidence also exists that sustainability issues are relevant to mainstream accounting research themes. Sustainability information is seen by many as supplemental to financial reporting, not a substitute for it. The two can co-exist, as performance and sustainability are not mutually exclusive. 2014; García-Sánchez, 2021; García-Sánchez, 2023; Ghisetti, 2021; Gray, 2010; Hahn & Figge, 2011; Ioannou & Serafeim, 2012; Khan et al., 2016; Kolk, 2008; Lozano, 2015; Michelon & Parbonetti, 2012; Montiel & Delgado-Ceballos, 2014; Ortiz-de-Mandojana & Bansal, 2016; Schaltegger et al., 2012). Boards should take a strategic view and factor sustainability into their decision-making processes to improve organizational resilience and long-term value.

4.4 RISK AND RESILIENCE

The relevance of Risk Management and Resilience. As previous research has shown, effective governance, as observed in listed companies, mitigates potential risks and fosters resilience. Boards of directors not only handle crises but are also responsible for the company's long-term risk management strategy. References: Aebi, et al. (2012), Arena, et al. (2010), Beasley, et al. (2005), Bromiley, et al. (2015), Florio & Leoni (2017), Fraser & Simkins (2010), Gatzert & Martin (2015), Hoyt & Liebenberg (2011), Kahupi, et al. (2021), Kaplan & Mikes (2012), Kurzhals, et al. (2020), Lam (2003), Lundqvist (2015), McShane, et al. 2011; Mikes 2011; Paape & Speklé 2012; Power 2009; Spira & Page 2003; Woods 2009). Boards are now required to embed enterprise risk management into their strategies and their implementation. This involves balancing the short-term imperative to maximize shareholder value with the longer-term goals of sustainability and innovation.

4.5 THEORIES

The final theme discusses the theoretical lenses employed in the governance papers, including Agency theory (Jensen & Meckling, 1976; Shleifer & Vishny, 1997; Zahra & Pearce, 1989), which looks at the role of monitoring (i.e., audit committees) and accountability, as well as Stewardship theory (Davis et al., 1997; Donaldson & Davis, 1991), which investigates trust and cooperation between boards of directors and other stakeholders. Resource dependence theory (Pfeffer & Salancik, 1978; Hillman & Dalziel, 2003) holds that boards of directors seek critical resources and legitimacy. Upper echelons theory (Hambrick & Mason, 1984; Carpenter et al., 2004; Hambrick, 2007). In addition to the well-established classical approaches to corporate governance, more recent research traditions can also be connected to the field. Linking classical and more recent approaches to corporate governance allows for an exploration of the influence of director values and their cognitive frames on firm performance (Aguilera & Jackson, 2003; Boyd, 1990; Daily et al., 2003; Eisenhardt, 1989; Finkelstein & Hambrick, 1996; Huse, 2007; Tosi et al., 2003; Useem, 1984; Westphal & Zajac, 1995).

We provide a brief introduction to the themes before elaborating on each in turn. Firstly, Table 1 summarizes the thematic analysis and provides a brief overview of the key findings from the extensive literature on the themes of board independence, diversity, sustainability, risk, and resilience, and how a variety of theoretical perspectives have been used to explore how these themes interact to shape the roles of contemporary Boards. Individual themes are then addressed in turn.

Table 1
Summary of Thematic Findings: Focus, Representative References, and Key Insights

Theme	Focus	Representative References	Key Insights
Board Independence	Board size, independence, accountability	Yermack (1996); Zahra & Pearce (1989); Nguyen & Nielsen (2010); Rashid (2018); Dalton et al. (1999); Fama & Jensen (1983); Daily et al. (2003); Hermalin & Weisbach (2003); Bhagat & Black (2002); Klein (2002); Brickley et al. (1994); Weisbach (1988); Hillman & Dalziel (2003); Westphal (1999); Anderson & Reeb (2004); Coles et al. (2008); Boone et al. (2007); Adams & Mehran (2003); Gillan (2006); Renneboog & Szilagyi (2011)	Independent boards reduce manipulation and improve transparency. Smaller boards are more effective, but independence in emerging markets is often symbolic.
Diversity	Gender and professional diversity	Bear et al. (2010); Byron & Post (2015); Joecks et al. (2013); Torchia et al. (2011); Carter et al. (2003); Adams & Ferreira (2009); Terjesen et al. (2009); Post & Byron (2016); Nielsen & Huse (2010); Singh et al. (2008); Hillman et al. (2007); Gul et al. (2011); Campbell & Mínguez-Vera (2008); Francoeur et al. (2008); Dezső & Ross (2012); Glass & Cook (2016); Sealy & Singh (2010); Konrad et al. (2008); Westphal & Milton (2000); Zhang (2020)	Diversity boosts CSR, reputation, and innovation. Tokenism persists, but once critical mass is reached, board dynamics and decision-making improve significantly.
Sustainability	ESG and governance integration	Ben-Amar et al. (2017); García-Sánchez (2021, 2023); Ghisetti (2021); Ortiz-de-Mandojana & Bansal (2016); Khan et al. (2016); Eccles et al. (2014); Ioannou & Serafeim (2012); Michelon & Parbonetti (2012); Clarkson et al. (2008); Dhaliwal et al. (2011); Cormier & Magnan (2007); Kolk (2008); Hahn & Figge (2011); Schaltegger et al. (2012); Lozano (2015); Bebbington & Larrinaga (2014); Gray (2010); Adams (2017); Dyllick & Muff (2016); Montiel & Delgado-Ceballos (2014)	Boards drive ESG disclosure and green innovation. Governance is reframed as legitimacy and competitive advantage, with sustainability becoming a strategic priority.
Risk & Resilience	Enterprise risk management, crisis response	Bromiley et al. (2015); Kahupi et al. (2021); Kuckertz et al. (2020); Kurzhals et al. (2020); Power (2009); Mikes (2011); Arena et al. (2010); Beasley et al. (2005); Lam (2003); Kaplan & Mikes (2012); Fraser & Simkins (2010); Paape & Speklé (2012); Lundqvist (2015); Woods (2009); Spira & Page (2003); Aebi et al. (2012); Florio & Leoni (2017); Gatzert & Martin (2015); McShane et al. (2011); Hoyt & Liebenberg (2011)	Strong governance structures reduce vulnerabilities and improve resilience. Boards are central in crisis response and long-term risk management strategies.
Theories	Agency, Stewardship, Resource Dependence, Upper Echelons	Jensen & Meckling (1976); Davis et al. (1997); Pfeffer & Salancik (1978); Hambrick & Mason (1984); Donaldson & Davis (1991); Hillman & Dalziel (2003); Eisenhardt (1989); Hambrick (2007); Zahra & Pearce (1989); Shleifer & Vishny (1997); Finkelstein & Hambrick (1996); Boyd (1990); Huse (2007); Daily et al. (2003); Carpenter et al. (2004); Westphal & Zajac (1995); Dalton et al. (2007); Aguilera & Jackson (2003); Tosi et al. (2003); Useem (1984)	Theories explain board behavior and decision-making. Cognitive frames and director values shape outcomes. Integrating classical and contemporary perspectives enriches governance research.

Source: elaborated by the authors.

5 DISCUSSION AND IMPLICATIONS

While the descriptive portrait of the boards offers insights into best practices, an analysis of multiple, intersecting dimensions of board governance—(in)dependence, diversity, sustainability, and risk management—and how they impact performance and legitimacy, will follow. These dimensions can be illuminated by theoretical frameworks and research regarding governance, accountability, and corporate governance of non-profit organizations. In discussing board characteristics, board independence is highlighted. As agency theory posits (Fama & Jensen, 1983; Zahra & Pearce, 1989), independent boards are perceived as effective at monitoring managers to limit opportunistic behavior. However, evidence suggests that independent boards are not always effective in emerging markets. For example, independent boards in family-dominated firms in emerging markets may be more of a ‘smoke screen,’ and owners continue to control the firm. Independent boards must be viewed within the context of the institutions and culture in which they operate. Findings on diversity are supported by insights from the resource dependence and upper echelons perspectives on boards. The findings suggest that boards with gender and professional diversity are positively associated with corporate social responsibility, social reputation, and innovation (Bear et al., 2010; Byron & Post, 2015; Joecks et al., 2013; Torchia et al., 2011). Recent studies have found that it is not just the presence of diverse members on boards that affects performance, but that a ‘critical mass’ of diverse board members can fundamentally change board dynamics and significantly improve decision-making (Joecks et al., 2013; Torchia et al., 2011). Diversity on boards is therefore a moral ‘must have’ but also a strategic ‘wedge’ that organizations can use to gain access to different networks, resources, and knowledge, thereby enhancing organizational adaptability. Sustainability findings show that ESG integration in governance has become a highly relevant, rapidly evolving issue. Sustainability is seen by boards as a source of legitimacy and as a competitive advantage. Disclosure and green innovation are core aspects of sustainability (Ben-Amar et al., 2017; García-Sánchez, 2021; Ortiz-de-Mandojana & Bansal, 2016). From an institutional theory perspective, corporate governance systems need to adapt to environmental and social expectations and address new regulations and challenges (Aguilera et al., 2021). Sustainability has moved from being a marginal issue to an important aspect of strategy and its implementation, placing the board at the forefront of embedding environmental and social responsibility into the corporate strategy. Risk and resilience research increasingly highlights the role of boards in enterprise risk management and crisis management. Good corporate governance can mitigate potential risks and strengthen resilience. To make strategic decisions, boards must integrate risk management into their day-to-day operations.

This challenge can be addressed by applying stewardship theory, which seeks to create long-term value while fostering trust. Implementing resilience is more than a simple task that can be solved by reacting to changing circumstances. Building up resilience requires boards to design governance and incorporate flexibility into business processes and structures on an ongoing basis. From a theoretical perspective, these findings are consistent across a number of frameworks concerning the nature and role of the board. The agency view of the board focuses on monitoring, the stewardship view positions governance about trusting, cooperating and managing well, the resource dependence view sees the board as a source of legitimate support and external resources for top management, and the upper echelons view identifies the cognitive frames and dominant values of the directors that influence board dynamics and decision-making (Jensen & Meckling, 1976; Donaldson & Davis, 1991; Pfeffer & Salancik, 1978; Hambrick & Mason, 1984). Incorporating these perspectives, therefore, provides a more complete understanding of the governance process and the board's monitoring role. The findings have significant implications for both practitioners and policymakers. For the practitioners, this means that boards must comprise the right mix of independent and non-independent directors to be effective, ensuring that independent directors are genuinely independent; pursuing diversity for moral and strategic reasons; and ensuring sustainability is a core strategic issue. In addition, risk management must shift from a defensive to a proactive role to build organizational resilience and value. From a policymakers' perspective, the findings suggest that the institutional environment in which boards operate needs to be strengthened so that independence and diversity translate into practice. For the scholar, moving beyond a single framework to a more holistic perspective of governance and its expression through organizational behaviors is critical to gaining a deeper, more nuanced understanding of the diversity of board dynamics and behaviors. Governance means bringing all these qualities to bear on a company's governance and viewing the matter from several angles. Viewing boards' role from this perspective reveals that their influence extends beyond simple oversight: they are strategic players whose actions have important consequences for a company's long-term legitimacy, resilience, and performance.

6 SIGNIFICANCE OF THE STUDY

This study on governance of organizations advances theory and practice by shedding new light on the dynamics of boards of directors. Effective governance is a multifaceted phenomenon that results from the dynamics of structural, behavioral, and contextual factors concerning governance practices such as board independence, diversity, sustainability, and

risk management. The study advances governance research by integrating relevant theoretical lenses, including agency theory, stewardship theory, the resource dependence perspective, and upper echelons theory, and analyzing how director values and their cognitive frames affect the performance of organizations. The paper contributes to the existing body of knowledge by attempting to synthesize the widely scattered knowledge base of boards' characteristics, themes, and relationships in a meaningful thematic analysis of patterns and relationships. The paper can also serve as a precursor to empirical studies conducted in emerging markets, where boards are currently largely independent but need greater diversity, sustainable strategies, and stronger risk management. The paper can also help clarify what constitutes "effective boards" not only in emerging markets but worldwide. Most importantly, the paper offers policymakers vital insights into how to create an institutional environment that enables the translation of corporate governance reforms into practice and outcomes.

7 CONCLUSION

This study explores the interconnections between board independence, diversity, sustainability, and risk management characteristics and how these dimensions interact to deliver effective governance. Our evidence suggests that effective governance arises from an integrated system in which structures, values, and context interact to shape organizational practices. Independent boards are found to enhance transparency and accountability; however, this is contingent on ownership structure and governance environment. Diversity is seen as a key strategic asset for boards and contributes to innovation, legitimacy, and corporate social responsibility, particularly when a tipping point in diversity is reached. Sustainability is revealed to be a key strategic priority for boards, critical to driving ESG disclosure and green innovation to build long-term resilience and gain a competitive advantage. As with any sector, Risk management highlights the Board's proactive role in ensuring the organization's strategies manage risks and that its strategic plans incorporate the enterprise risk framework. The Board needs to assess the organization's flexibility and responsiveness to address uncertainty. Grounded in agency theory, stewardship theory, resource dependence theory, and upper echelons theory, this study examines the relationships between governance characteristics and organizational performance. This study makes a methodological contribution to the governance research stream by employing both bibliometric mapping and thematic synthesis to provide a structured framework for synthesizing the current literature to identify emerging trends and new areas of inquiry. The boards of directors are not only guardians of oversight, but also strategic managers in governance and execution. Practicing independence, diversity, and sustainability, and

managing risks are key to organizational legitimacy, resilience, and performance. Future research could focus on emerging markets, where the substantive impact of governance reforms is constrained by weaker institutional environments. In addition, research could examine how digitalization and global sustainability themes are shifting the focus of boards of directors. This study offers theoretical and practical insights into the boards of directors' essential role in shaping the enterprise's future as a sustainable, resilient business.

8 FUTURE RESEARCH

The findings of this study offer potential avenues for future research on board governance, its determinants, and outcomes. Firstly, future studies can be conducted in emerging markets where independent boards remain myths due to dominant shareholders and a poor institutional environment (Nguyen & Nielsen, 2010; Rashid, 2018). Comparative studies that analyze countries with different institutional and governance systems help us understand how independent boards translate into meaningful accountability across strong and weak institutions. Although significant progress has been made in empirical research on boards, there is a growing call for more theoretical contributions to the field, underscoring the need to apply multiple theoretical frameworks to better understand board dynamics. In particular, incorporating agency theory, stewardship theory, resource dependence theory, and upper echelons theory can facilitate a deeper, more comprehensive understanding of boards' behavior. Also, applying behavioral governance and institutional logics to explain directors' decisions would be worthwhile. Using thematic analysis in conjunction with bibliometric mapping is a powerful methodology that could be further extended through more advanced visualization techniques and mixed-methods research. Future research could address the governance of sustainability in new territories, such as the biotic Commons; incorporate new dimensions of diversity; adopt a broader perspective on sustainability; and benefit from a more integrated application of social science theories.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the authors used Grammarly, in order to improve grammar accuracy, ensure clarity of expression, and refine sentence flow and enhance readability. Microsoft Copilot was used to support idea organization, provide suggestions for strengthening academic style, and to compose the cover letter. After using

these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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SNAKEBITE ACCIDENTS IN THE AMAZON AND THEIR LOCAL COMPLICATIONS: TISSUE NECROSIS ASSOCIATED WITH PREDOMINANT SPECIES IN THE STATE OF AMAZONAS

ACIDENTES OFÍDICOS NA AMAZÔNIA E SUAS COMPLICAÇÕES LOCAIS: NECROSE TECIDUAL ASSOCIADA ÀS ESPÉCIES PREDOMINANTES NO AMAZONAS

ACCIDENTES OFÍDICOS EN LA AMAZONÍA Y SUS COMPLICACIONES LOCALES: NECROSIS TISULAR ASOCIADA A LAS ESPECIES PREDOMINANTES EN EL ESTADO DE AMAZONAS



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ABSTRACT

Snakebite accidents represent a significant public health issue, particularly in the Amazon region, where environmental and occupational factors, along with high biodiversity, increase human exposure to venomous snakes. In this context, the genus *Bothrops* stands out as the main cause of envenomation, often associated with severe local complications such as tissue necrosis. This study aimed to analyze snakebite accidents in the Amazon and their local complications, with emphasis on tissue necrosis associated with predominant species in the state of Amazonas. This is a qualitative, exploratory, and descriptive study conducted through a literature review of scientific articles published between 2021 and 2026, selected from relevant health science databases. The findings indicate that *Bothrops atrox* is the primary species involved in snakebite cases in the region, responsible for intense local clinical manifestations such as edema, pain, hemorrhage, and tissue necrosis. Furthermore, the severity of complications is directly related to the time to medical care and the amount of venom injected, potentially leading to permanent sequelae and significant impacts on patients' quality of life. It is concluded that snakebite accidents in the Amazon constitute a complex phenomenon with important clinical and social implications, highlighting the need for effective strategies for prevention, early diagnosis, and appropriate treatment.

Keywords: Amazon. *Bothrops Atrox*. Envenomation. Snakebite Accidents. Tissue Necrosis.

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RESUMO

Os acidentes ofídicos representam um importante problema de saúde pública, especialmente na região amazônica, onde fatores ambientais, ocupacionais e a elevada biodiversidade favorecem o contato entre humanos e serpentes peçonhentas. Nesse contexto, destaca-se o gênero *Bothrops*, responsável pela maioria dos envenenamentos na região, frequentemente associado a complicações locais graves, como a necrose tecidual. O presente estudo teve como objetivo analisar os acidentes ofídicos na Amazônia e suas complicações locais, com ênfase na necrose tecidual associada às espécies predominantes no estado do Amazonas. Trata-se de uma pesquisa de natureza qualitativa, com caráter exploratório e descritivo, desenvolvida por meio de revisão bibliográfica de artigos científicos publicados entre 2021 e 2026, selecionados em bases de dados relevantes da área da saúde. Os resultados evidenciam que *Bothrops atrox* é a principal espécie envolvida nos acidentes na região, sendo responsável por manifestações clínicas locais intensas, como edema, dor, hemorragia e necrose tecidual. Observou-se ainda que a gravidade das complicações está diretamente relacionada ao tempo de atendimento e à quantidade de veneno inoculado, podendo resultar em sequelas permanentes e impacto significativo na qualidade de vida dos indivíduos afetados. Conclui-se que os acidentes ofídicos na Amazônia constituem um fenômeno complexo, com importantes implicações clínicas e sociais, reforçando a necessidade de estratégias eficazes de prevenção, diagnóstico precoce e tratamento adequado.

Palavras-chave: Acidentes Ofídicos. Amazônia. *Bothrops Atrox*. Envenenamento. Necrose Tecidual.

RESUMEN

Los accidentes ofídicos representan un importante problema de salud pública, especialmente en la región amazónica, donde factores ambientales, ocupacionales y la alta biodiversidad favorecen el contacto entre humanos y serpientes venenosas. En este contexto, el género *Bothrops* se destaca como el principal responsable de los envenenamientos, frecuentemente asociado a complicaciones locales graves, como la necrosis tisular. El presente estudio tuvo como objetivo analizar los accidentes ofídicos en la Amazonía y sus complicaciones locales, con énfasis en la necrosis tisular asociada a las especies predominantes en el estado de Amazonas. Se trata de una investigación de naturaleza cualitativa, con carácter exploratorio y descriptivo, desarrollada mediante revisión bibliográfica de artículos científicos publicados entre 2021 y 2026, seleccionados en bases de datos relevantes del área de la salud. Los resultados evidencian que *Bothrops atrox* es la principal especie involucrada en los accidentes en la región, siendo responsable de manifestaciones clínicas locales intensas como edema, dolor, hemorragia y necrosis tisular. Asimismo, se observó que la gravedad de las complicaciones está directamente relacionada con el tiempo de atención médica y la cantidad de veneno inoculado, pudiendo resultar en secuelas permanentes y un impacto significativo en la calidad de vida de los individuos afectados. Se concluye que los accidentes ofídicos en la Amazonía constituyen un fenómeno complejo, con importantes implicaciones clínicas y sociales, lo que refuerza la necesidad de estrategias eficaces de prevención, diagnóstico precoz y tratamiento adecuado.

Palabras clave: Accidentes Ofídicos. Amazonía. *Bothrops Atrox*. Envenenamiento. Necrosis Tisular.

1 INTRODUCTION

Snakebites are a relevant public health problem in several tropical regions of the world, especially in countries with great biodiversity and extensive natural areas, such as Brazil. In the Amazon region, this scenario becomes even more expressive due to the intense interaction between human populations and the forest environment, which favors contact with venomous snakes. According to Scheliga (2024), the epidemiology of snakebite accidents in Brazil is more concentrated in the North region, highlighting the need for studies focused on the environmental and social specificities of the Amazon.

In this context, the genus *Bothrops* stands out as the main responsible for snakebite accidents in the country, and the species *Bothrops atrox* is widely associated with the cases registered in the Amazon region. This predominance is related both to the wide geographical distribution of these snakes and to their adaptive behavior in environments close to human activity. As Silva (2023) points out, bothrops accidents represent the majority of cases of snake envenomation in Brazil, especially in tropical forest areas, where there is greater occupational and environmental exposure.

From a clinical point of view, accidents caused by snakes of the genus *Bothrops* have local and systemic manifestations that can evolve into severe conditions when not treated properly. Among the most relevant local complications, tissue necrosis stands out, characterized by the progressive destruction of tissues at the site of the bite, which may result in permanent sequelae. According to Nascimento (2024), tissue damage resulting from bothrops envenomation often requires prolonged hospital follow-up, especially in cases where there is significant muscle involvement.

In addition to the clinical aspects, snakebites also have important social and economic impacts, since they affect, for the most part, individuals of working age, especially rural workers and populations that depend directly on the natural environment for their subsistence. In this sense, Fernández (2025) highlights that the sequelae resulting from tissue necrosis can compromise the functional capacity of individuals, directly impacting their quality of life and work activities.

In view of this scenario, it is essential to understand the factors involved in the occurrence of snakebites in the Amazon, as well as the local complications associated with envenomation, with emphasis on tissue necrosis. The analysis of these elements allows not only to expand scientific knowledge on the subject, but also to contribute to the development of more effective prevention, diagnosis, and treatment strategies.

2 THEORETICAL FRAMEWORK

Snakebites represent an important public health problem in tropical regions, especially in areas of the Brazilian Amazon, where the interaction between human populations and natural environments favors the occurrence of snake envenomation. Recent studies indicate that Brazil registers thousands of cases annually, with the North region responsible for a significant portion of these records. In this context, the high biodiversity of snakes and the presence of rural, extractive and forestry activities increase the risk of exposure of the population to snakebites. As demonstrated by Scheliga (2024), the epidemiology of snake accidents in Brazil is strongly concentrated in Amazonian areas, which highlights the need for studies directed to the ecological and clinical particularities of this region.

Among the snakes responsible for accidents in the Amazon, the genus *Bothrops* stands out, whose geographic distribution and behavior contribute to the high incidence of envenomation. The species *Bothrops atrox* is considered the main responsible for snakebites in the Amazon region, and is often associated with severe clinical manifestations. According to Silva (2023), botrosopic accidents represent most of the cases recorded in the country, especially in tropical forest regions, where environmental conditions favor the abundance of these snakes. In addition, Amaral (2024) observes that the diversity of species involved in tropical snakebites reinforces the epidemiological complexity of the problem, requiring specific regional approaches to understand the dynamics of these events.

In the clinical context, accidents caused by snakes of the genus *Bothrops* are characterized by systemic and local manifestations resulting from the action of the venom. Among the most relevant local complications are edema, hemorrhage, severe pain, and tissue necrosis, conditions that can evolve into permanent sequelae when treatment is not carried out quickly and adequately. According to Nascimento (2026), envenomation by *Bothrops atrox* can trigger serious complications, such as compartment syndrome, as a result of the intense inflammatory response and vascular impairment caused by the toxins present in the venom. These local effects represent one of the main causes of morbidity associated with snakebite accidents in the Amazon.

The pathophysiology of tissue necrosis associated with botrosopic accidents is directly related to the action of proteolytic enzymes, metalloproteinases and phospholipases present in snake venom. These substances promote cell destruction, vascular changes, and inflammatory processes that lead to tissue degradation at the bite site. Nascimento (2024) highlights that local damage caused by bothrops envenomation may require prolonged hospital care, especially when there is significant muscle and skin involvement. In this sense, understanding the pathophysiological mechanisms involved in tissue necrosis becomes

essential for the development of more effective therapeutic strategies and for reducing the sequelae resulting from these accidents.

In addition to local pathophysiological changes, snakebites caused by snakes of the genus *Bothrops* can also have long-term functional consequences. Complications from tissue necrosis often result in permanent physical limitations, especially when there is a delay in medical care or when treatment is not carried out properly. In this sense, Fernández (2025) highlights that victims of botropic accidents in the Amazon can present lasting sensory and motor sequelae, compromising the quality of life and work capacity of affected individuals. These consequences show that the impact of snakebite accidents goes beyond the acute phase of envenomation, configuring itself as a public health problem that also involves social and economic aspects.

The epidemiological analysis of snakebite accidents in Brazil shows that certain population groups are more vulnerable to this type of occurrence. In general, rural workers, farmers, fishermen and populations living in areas close to forest environments are more exposed to the risk of contact with snakes. According to Silva (2023), accidents by snakes of the genus *Bothrops* predominantly affect male individuals of productive age, reflecting the association between work activities and environmental exposure. This epidemiological profile reinforces the importance of preventive strategies aimed at populations living or working in regions at higher risk.

Another relevant aspect refers to the diversity of species responsible for snakebite accidents in the Amazon, which contributes to the variability of the clinical manifestations observed in patients. Although *Bothrops atrox* is the main species involved in envenomations in the region, other representatives of the genus may also be associated with accidents with similar clinical manifestations. In this context, Oliveira Pardal (2023) reports records of envenomation by *Bothrops brazili* in the Brazilian Amazon, showing that different species can cause complex clinical conditions and require an appropriate therapeutic approach. The correct identification of the species involved in the accident is, therefore, a relevant element for the clinical and epidemiological management of cases.

In addition to the diversity of species, environmental and ecological factors also influence the occurrence of snakebites in the Amazon region. The proximity between urbanized areas and natural environments favors increased contact between humans and snakes, especially in regions where agricultural and extractive activities are predominant. Siqueira (2025) observes that the spatial distribution of snakebites in the North region is directly related to local environmental characteristics, such as vegetation cover, rainfall and the presence of rural areas. Thus, understanding the ecological dynamics of snakes becomes

essential for the planning of public policies aimed at preventing and controlling these accidents.

Another relevant aspect in the theoretical framework on snakebite accidents in the Amazon refers to the clinical complications resulting from envenomation, especially those associated with local tissue involvement. The toxins present in the venom of snakes of the genus *Bothrops* have strong proteolytic and hemotoxic activity, which contributes to the progressive destruction of tissues at the bite site. This process can result in extensive necrosis, often accompanied by severe edema and local hemorrhage. In this sense, studies indicate that the intensity of these manifestations is directly related to the amount of venom inoculated and the time elapsed until the start of treatment. Amaral (2024) points out that the complexity of the toxins present in bothrops venom contributes to the diversity of clinical manifestations observed in patients, which makes the clinical management of these accidents a constant challenge in health services.

Tissue necrosis resulting from botrosopic accidents represents one of the main causes of morbidity associated with snake envenomation in the Amazon region. This condition can progress to secondary infections, loss of muscle tissue, and, in more severe cases, the need for surgical procedures or amputations. Nascimento (2024) highlights that patients affected by *Bothrops atrox* envenomation often require prolonged hospital follow-up due to the severity of local lesions and complications resulting from the inflammatory process triggered by the venom. This scenario highlights the importance of early diagnosis and proper administration of antivenom as fundamental measures to reduce tissue damage.

In addition to the immediate clinical manifestations, snakebites can have lasting impacts on the health of affected individuals. The physical sequelae resulting from tissue necrosis can significantly compromise the functionality of the affected limbs, limiting daily and professional activities. Fernández (2025) observes that individuals who are victims of botropes in the Amazon often have persistent sensory and motor limitations, as a result of the tissue destruction caused by the venom. These consequences demonstrate that snakebites should not only be analyzed from an acute clinical perspective, but also considering the long-term effects on the quality of life of exposed populations.

Another important element in understanding the complications associated with snakebites concerns the therapeutic strategies employed in the treatment of these envenomations. Antivenom continues to be the main therapeutic resource used in the clinical management of these cases, acting to neutralize the toxins present in the venom. However, the effectiveness of the treatment is directly related to the time of administration and the clinical conditions of the patient at the time of care. Teixeira (2024) points out that the search

for complementary therapeutic alternatives has been the subject of scientific investigation, especially with regard to the control of local complications, such as necrosis and tissue inflammation. Thus, the expansion of knowledge about the mechanisms of action of the venom and about the forms of therapeutic intervention is an essential step towards improving the clinical management of snakebites.

3 METHODOLOGY

The present research is characterized as a qualitative study of exploratory and descriptive character, developed through a literature review. This type of approach allows a critical analysis of the scientific knowledge already produced about a given phenomenon, making it possible to understand the main theoretical perspectives, scientific advances, and gaps in the literature. The choice of this methodological design is justified by the need to gather and analyze recent scientific evidence on snakebites in the Amazon and their local complications, especially those related to tissue necrosis associated with the predominant species in the state of Amazonas.

The universe of the research consisted of scientific articles published in national and international academic journals that address snakebites, envenomation by snakes of the genus *Bothrops*, clinical complications associated with envenomation and epidemiological aspects of these accidents in the Amazon region. The sample consisted of ten scientific articles published in the last five years, selected for their thematic relevance and scientific contribution to the understanding of the clinical manifestations and local complications resulting from snake envenomation.

Data collection was carried out through a systematic search in scientific databases widely used in the area of health and biological sciences, including academic indexing platforms and repositories of scientific journals. Descriptors related to the research theme were used, such as snakebite, *snakebite*, tissue necrosis, *Bothrops atrox*, bothrops envenomation and Amazonia. These descriptors were strategically combined to expand the scope of the search and identify relevant scientific studies published in the period delimited for the investigation.

After the initial identification of the publications, a screening stage of the studies was carried out based on previously defined inclusion and exclusion criteria. Scientific articles published between 2021 and 2026, available in full format, and that had a direct relationship with snakebites, pathophysiology of envenomation, clinical manifestations, or complications associated with tissue necrosis were included. Studies that did not have a direct relationship with the topic investigated, duplicate publications, or studies that did not provide access to

the full text were excluded.

Data analysis was conducted through analytical and interpretative reading of the selected studies, seeking to identify convergences, divergences and relevant contributions to the understanding of the investigated phenomenon. In this process, aspects such as the objectives of the research, the methods used, the main results found and the clinical and epidemiological implications of snakebites described in the analyzed studies were examined. From this analysis, it was possible to systematize the existing knowledge about the occurrence of these accidents in the Amazon and about the local complications resulting from poisoning.

Like all research based on literature review, the present study has some methodological limitations. Among them, the dependence on the availability of published studies on the subject stands out, as well as possible methodological differences between the studies analyzed. Even so, the use of recent scientific articles from recognized journals contributes to strengthen the consistency of the information analyzed and to expand the scientific understanding of snakebites and their local complications in the Amazon region.

The literature review carried out in this research allowed the identification of recent studies that address epidemiological, clinical and pathophysiological aspects of snakebites, with emphasis on the predominant species in the Amazon and the local complications resulting from envenomation.

The selected studies contribute to understanding the dynamics of these accidents, the mechanisms of action of the venom and the associated clinical impacts, especially with regard to tissue necrosis and the sequelae resulting from bothrops envenomation. The following table presents the main authors used in the construction of the theoretical framework, as well as the titles of the works and the respective years of publication.

Table 1

Authors used in the research

Author	Title	Year
Amaral	<i>Snakes involved in snakebites in tropical regions of Brazil</i>	2024
Fernández	<i>Physical and sensory long-term disabilities from Bothrops snakebites in the western Brazilian Amazon</i>	2025
Birth	<i>Acute compartment syndrome in Bothrops atrox snakebites</i>	2026
Birth	<i>Long-term hospital care needs after Bothrops atrox envenomation</i>	2024

Author	Title	Year
Oliveira Parda	First record of envenomation by <i>Bothrops brazili</i> in the Brazilian Amazon	2023
Scheliga	Exploring snakebite epidemiology and outcomes in Brazil	2024
Siqueira	Epidemiology and clinical characteristics of snakebite accidents in the Northern region of Brazil	2025
Silva	Who are the most affected by <i>Bothrops</i> snakebite envenoming in Brazil	2023
Souza	Botrosopic accidents in Brazil, a brief review	2024
Teixeira	Therapeutic alternatives for the treatment of snakebites	2024

Source: The authors.

From the studies presented in the table, it is observed that the recent scientific literature has directed significant attention to the epidemiological, clinical and therapeutic aspects of snakebites, especially those related to snakes of the genus *Bothrops*, predominant in the Amazon.

The analyzed studies show the relevance of the theme for public health, highlighting both the pathophysiological mechanisms of envenomation and local complications, such as tissue necrosis, in addition to the functional and social consequences resulting from these accidents. Thus, the joint analysis of these studies contributes to theoretically support the investigation proposed in this study.

4 RESULTS AND DISCUSSIONS

The analysis of the selected studies allowed us to identify that snakebite accidents continue to represent a relevant public health problem in Brazil, especially in the Amazon region, where environmental, social and occupational factors contribute to the higher incidence of these events. The results found in the literature show that snakes of the genus *Bothrops* are responsible for most of the accidents recorded in the Amazon, with *Bothrops atrox* being the species most frequently associated with cases of human envenomation. In this context, epidemiological studies show that the distribution of these accidents is strongly related to the proximity between human populations and natural environments, in addition to the performance of work activities in rural or forest areas. Scheliga (2024) highlights that the epidemiological pattern of snakebite accidents in Brazil is strongly concentrated in tropical regions, particularly in the Amazon, where the diversity of snakes and environmental characteristics favor increased contact between humans and these animals.

In addition to the high incidence of these accidents in the Amazon region, the results

analyzed indicate that certain populations are more vulnerable to snake envenomation. In general, the individuals most affected are rural workers, farmers, fishermen and populations living in areas close to the forest. According to Silva (2023), accidents caused by snakes of the genus *Bothrops* predominantly affect male individuals of economically active age, which highlights the direct relationship between occupational activities and risk of exposure to envenomation. This epidemiological profile also reinforces the need for public policies aimed at preventing these accidents, including educational actions and health surveillance strategies in regions considered to be at higher risk.

Another relevant aspect identified in the analyzed studies refers to the clinical manifestations associated with bothrops envenomation, especially with regard to local complications resulting from the action of the venom. The data indicate that envenomation by *Bothrops atrox* is often associated with intense local manifestations, such as pain, edema, hemorrhage, and tissue necrosis. Nascimento (2026) observes that the action of the toxins present in the venom of these snakes can cause significant vascular and inflammatory damage, leading to the development of serious complications, such as compartment syndrome. This clinical picture results from increased pressure in the muscle compartments, caused by intense edema and vascular involvement, which can lead to permanent damage to the affected tissues.

The results also show that tissue necrosis represents one of the main local complications associated with botrosopic accidents in the Amazon. This process occurs as a result of the action of enzymes present in the venom, which promote degradation of structural proteins and compromise local microcirculation. Amaral (2024) points out that the diversity of toxins present in the venom of snakes of the genus *Bothrops* contributes to the complexity of the clinical manifestations observed in patients, especially with regard to tissue lesions and intense inflammatory processes at the bite site. In this sense, the studies analyzed indicate that tissue necrosis can evolve rapidly when there is no adequate therapeutic intervention, increasing the risk of severe complications and permanent sequelae.

Another relevant result identified in the literature concerns the functional and social impact resulting from complications associated with snakebites. Tissue injuries caused by envenomation can result in long-term physical disabilities, significantly compromising the quality of life of affected individuals. Fernández (2025) points out that victims of botrosopic accidents in the Amazon often have persistent motor and sensory sequelae, resulting from the destruction of muscle and nerve tissues caused by the toxins in the venom. These consequences show that snakebites should not be analyzed only from the perspective of the

acute phase of envenomation, but also considering the lasting effects that can impact the social and economic life of the affected populations.

The results presented in this stage demonstrate that snakebites in the Amazon involve a complex set of epidemiological, environmental and clinical factors, which contribute to the occurrence of severe local complications, such as tissue necrosis. The analysis of the selected studies reinforces the importance of understanding the dynamics of these accidents and the pathophysiological mechanisms involved in bothrops envenoming, in order to expand scientific knowledge on the subject and contribute to the improvement of strategies for the prevention, diagnosis, and treatment of these diseases.

The discussion of these results continues in the next section, in which other scientific evidence related to clinical complications and therapeutic approaches used in the management of snakebite events will be analyzed.

The analysis of the selected studies also highlighted the importance of identifying the species involved in snakebites for an adequate understanding of the clinical manifestations and complications associated with envenomation. Although *Bothrops atrox* is recognized as the main species responsible for accidents in the Amazon, other representatives of the genus may also be associated with relevant clinical cases in the region. In this context, Oliveira Parda (2023) records the occurrence of envenomation by *Bothrops brazili* in the Brazilian Amazon, highlighting that different species may present variations in the composition of the venom and, consequently, in the clinical manifestations observed in patients. This biological diversity contributes to the complexity of the clinical diagnosis and reinforces the need for greater knowledge about the regional snakebite.

Another relevant result identified in the analyzed studies refers to the time of medical care as a determining factor for the clinical evolution of patients who are victims of snakebites. The literature indicates that the speed of administration of antivenom plays a fundamental role in reducing the local and systemic complications of envenomation. Nascimento (2024) highlights that patients who receive late care are more likely to develop extensive tissue lesions and complications that require prolonged hospital follow-up. Thus, the availability of health services in remote areas of the Amazon is an essential element for reducing the morbidity associated with snake accidents.

In addition, the results indicate that tissue necrosis resulting from bothrops envenomation has a significant impact on the clinical evolution of patients, and may result in permanent functional loss of the affected limbs. Amaral (2024) points out that the toxins present in the venom of snakes of the genus *Bothrops* have a high capacity to cause cell destruction and local inflammation, favoring the development of extensive lesions in the

affected tissues. This pathological process can progress to severe conditions when there is no adequate therapeutic intervention or when treatment is carried out late, increasing the risk of irreversible sequelae.

Another relevant point identified in the literature analysis refers to the epidemiological characteristics of snakebite accidents in the northern region of Brazil. Siqueira (2025) observes that the occurrence of these accidents is often associated with rural areas and forest regions, where activities such as agriculture, extractivism, and fishing expose populations to contact with snakes. This epidemiological pattern shows that snakebites are not random events, but rather phenomena strongly influenced by environmental and socioeconomic factors present in the Amazon region.

The studies analyzed also point to the need for the development and improvement of therapeutic strategies capable of reducing the complications associated with snake envenomation. Although antivenom continues to be the main therapeutic resource used in the treatment of these accidents, recent research indicates the importance of complementary approaches aimed at controlling local complications.

Teixeira (2024) highlights that new therapeutic alternatives have been investigated with the aim of minimizing tissue damage and improving the prognosis of patients who are victims of snakebites. These findings reinforce the relevance of expanding scientific knowledge about the mechanisms of action of the venom and about the treatment strategies capable of reducing the sequelae resulting from these accidents.

The discussion of the results also shows that snakebites have impacts that go beyond the immediate clinical dimension, configuring themselves as a problem that involves social, economic and structural aspects, especially in regions of difficult access such as the Amazon. The studies analyzed indicate that the occurrence of these accidents is often associated with rural communities and forest areas, where access to health services may be limited. In this sense, Scheliga (2024) observes that the geographical distribution of snakebite accidents in Brazil reveals a higher incidence in tropical regions, in which environmental and socioeconomic factors directly influence the risk of exposure to snakes.

Another important aspect identified in the studies refers to the functional consequences resulting from the lesions caused by bothrops envenomation. Tissue necrosis, often seen in these cases, can result in loss of muscle mass, impairment of nerve structures, and permanent limitations of the affected limbs. Fernández (2025) points out that the sequelae associated with accidents by snakes of the genus *Bothrops* can generate long-lasting physical disabilities, compromising the victims' work capacity and quality of life. These results demonstrate that snakebites should be analyzed not only from a clinical perspective,

but also considering their social and economic effects on the affected populations.

The integrated analysis of the selected studies also allows us to observe that the complexity of *Bothrops* envenomation is related to the diversity of toxins present in the venom of these snakes. Amaral (2024) points out that the biochemical composition of the venom can vary between species and even between populations of the same species, influencing the intensity of the clinical manifestations observed in patients. This variability contributes to the diversity of clinical conditions recorded in snakebite accidents and reinforces the need for further research on the pathophysiology of envenomation and its local complications.

In addition, the results discussed indicate that epidemiological knowledge about snakebites is an essential tool for planning strategies for the prevention and control of these diseases. Studies such as those by Silva (2023) and Siqueira (2025) show that the identification of the population groups most exposed to the risk of accidents allows for the direction of public policies and educational actions aimed at reducing the incidence of these events. Thus, prevention measures, training of health professionals and expansion of access to appropriate treatment become essential to reduce the impacts of snakebite accidents in the Amazon region.

In general, the analysis of the selected studies demonstrates that snakebites in the Amazon represent a complex phenomenon, influenced by biological, environmental and social factors. The high incidence of these accidents, associated with local complications such as tissue necrosis, highlights the need to expand scientific knowledge on the subject and strengthen prevention and treatment strategies. In this context, the integration between scientific research, public health policies, and health education actions is essential to reduce the morbidity associated with snake envenomation and improve the quality of life of populations exposed to this risk.

The systematized analysis of the selected studies allowed the identification of different methodological approaches and scientific objectives aimed at understanding snakebites, especially those associated with snakes of the genus *Bothrops* in the Amazon. The studies analyzed range from epidemiological and clinical aspects to discussions on local complications and therapeutic strategies used in the management of envenomation.

The organization of this information in a table allows us to visualize in a comparative way the contributions of each study to the understanding of the investigated phenomenon. Thus, the following table presents the main authors used in the research, as well as the objectives, methods used and the main results found in each study.

Table 2

Synthesis of the studies used in the research

Authors	Objective	Method	Main results
Amaral	To analyze snake species involved in snakebite accidents in tropical regions	Literature review	He identified a predominance of snakes of the genus <i>Bothrops</i> in snakebites and highlighted the diversity of toxins present in the venom, associated with local complications such as tissue necrosis
Fernández	To investigate the physical and sensory sequelae resulting from botropic accidents in the Amazon	Observational study	Demonstrated that victims of <i>Bothrops</i> poisoning may have long-term motor and sensory limitations
Birth (2026)	To evaluate clinical complications associated with <i>Bothrops atrox</i> poisoning	Clinical study	It showed the occurrence of serious complications, such as compartment syndrome and tissue damage associated with the action of toxins
Birth (2024)	To analyze the need for long-term hospital care after bothrops poisoning	Clinical study and case analysis	It indicated that severe local injuries may require prolonged hospital treatment and medical follow-up
Oliveira Parda	To record and analyze cases of envenomation by <i>Bothrops brazili</i> in the Amazon	Case report	It showed that different species of the genus <i>Bothrops</i> can cause complex clinical conditions
Scheliga	To investigate the epidemiological profile of snakebite accidents in Brazil	Epidemiological study	It identified a higher concentration of accidents in tropical regions and association with environmental factors
Siqueira	To analyze epidemiological characteristics of snakebite accidents in the North region	Epidemiological study	It demonstrated a relationship between snakebites, rural activities and forest environments
Silva	To identify the population groups most affected by botrosopic accidents in Brazil	Epidemiological study	It indicated a predominance of male victims of working age
Souza	To review the literature on botrosopic accidents in Brazil	Literature review	He highlighted the main clinical and epidemiological aspects of bothrops envenomation
Teixeira	To investigate therapeutic alternatives for the treatment of snakebites	Literature review	He indicated the importance of complementary therapies to antivenom to reduce local complications

Source: The authors.

From the synthesis presented in the table, it is observed that the studies analyzed converge in pointing out the predominance of accidents caused by snakes of the genus *Bothrops* in the Amazon region, as well as the relevance of local complications associated with envenomation, especially tissue necrosis.

In general, the research highlights both the epidemiological aspects of these accidents and the clinical and functional implications resulting from the injuries caused by the venom, evidencing the importance of expanding scientific knowledge on the subject to support more effective prevention, diagnosis and treatment strategies.

5 CONCLUSION

The present study achieved the proposed objective by analyzing the application of the protection of sensitive personal data in the health area, evidencing the relevance of adapting to current regulations and the need for more rigorous practices in the treatment of this information. The investigation allowed us to understand that health data, due to its highly sensitive nature, requires not only legal compliance, but also an ethical commitment on the part of the institutions and professionals involved.

Despite the advances in the adoption of data protection measures, there are still important flaws, such as the lack of standardization of procedures, the need for greater training of professionals, and the insufficiency in monitoring compliance with the rules.

In addition, it was found that the adoption of good practices, such as the implementation of clear internal policies, investment in information security technologies and the awareness of the agents involved, contributes significantly to risk mitigation. In this sense, data protection in health should not be understood only as a legal obligation, but as an essential element for the quality of care and trust between patients and institutions.

The questions raised in the introduction were duly answered, demonstrating that the effective application of the rules depends on the integration between technical, legal and organizational aspects. The hypotheses initially considered can be classified as partially confirmed, since, despite the existence of adequate legal mechanisms, their practical application still faces relevant challenges.

Finally, the importance of continuing studies in the area is highlighted, especially in the face of constant technological transformations and the growing volume of data generated in the health sector. Future investigations can deepen the analysis of more effective implementation and monitoring strategies, contributing to the continuous improvement of the protection of sensitive personal data.

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In particular, the honor of being able to contribute to the dissemination of scientific knowledge produced from the reality of the Amazon is registered. The region is home to one of the greatest biodiversity on the planet and presents unique challenges for science and public health. Spreading this knowledge to the international scientific community represents not only an academic commitment, but also a way of valuing the environmental, social, and cultural richness of the Amazon, expanding the visibility of its issues and strengthening scientific dialogue with the world.

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GRAFTING OF BIOMODELS PRODUCED BY ADDITIVE MANUFACTURING USING ACRYLONITRILE BUTADIENE STYRENE (ABS) IN RABBIT TIBIAS

ENXERTO DE BIOMODELOS EM ACRILONITRILA BUTADIENO ESTIRENO (ABS) PRODUZIDOS POR MANUFATURA ADITIVA EM TÍBIAS DE COELHOS

INJERTO DE BIOMODELOS PRODUCIDOS POR MANUFACTURA ADITIVA CON ACRILONITRILO BUTADIENO ESTIRENO (ABS) EN TIBIAS DE CONEJOS



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ABSTRACT

Additive manufacturing has emerged as a promising technology in the healthcare field, particularly in the development of biomodels and customized implants. This study aimed to evaluate the use of acrylonitrile butadiene styrene (ABS) biomodels produced by 3D printing as grafts in rabbit tibias. Six New Zealand rabbits were used, receiving screw-shaped implants measuring 7 mm in length. The implants were sterilized either by autoclaving or immersion in glutaraldehyde. Animals were clinically evaluated until the third postoperative day and radiographically assessed at 0, 30, and 60 days. After this period, euthanasia was performed followed by macroscopic evaluation of the implants. ABS demonstrated low tissue reactivity, absence of rejection, and signs of osteointegration. Although autoclave sterilization resulted in slight deformation, it did not impair implantation. These findings suggest that ABS has potential for use in the development of customized orthopedic implants, although further long-term studies are required.

Keywords: Biomodels. Bone implants. Polymers. Rabbits. 3D printing.

RESUMO

A manufatura aditiva tem se destacado como uma tecnologia promissora na área da saúde, especialmente no desenvolvimento de biomodelos e implantes personalizados. O presente estudo teve como objetivo avaliar a utilização de biomodelos em acrilonitrila butadieno estireno (ABS), produzidos por impressão 3D, como enxertos em tíbias de coelhos. Foram

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utilizados seis coelhos da raça Nova Zelândia, nos quais foram implantados dispositivos em formato de parafusos com 7 mm de comprimento. Os implantes foram esterilizados por autoclave ou por imersão em glutaraldeído. Os animais foram avaliados clinicamente até o terceiro dia pós-operatório e radiograficamente aos 0, 30 e 60 dias. Após esse período, foi realizada a eutanásia e avaliação macroscópica dos implantes. Observou-se que o ABS apresentou baixa reatividade tecidual e ausência de sinais de rejeição, com evidências de osteointegração. Embora a esterilização em autoclave tenha causado leve deformação dos implantes, não houve comprometimento da implantação. Os resultados indicam que o ABS apresenta potencial para aplicação na produção de implantes ortopédicos personalizados, sendo necessários estudos adicionais para avaliação a longo prazo.

Palavras-chave: Biomodelos. Coelhos. Implantes ósseos. Impressão 3D. Polímeros.

RESUMEN

La manufactura aditiva ha surgido como una tecnología prometedora en el área de la salud, especialmente en el desarrollo de biomodelos e implantes personalizados. El presente estudio tuvo como objetivo evaluar el uso de biomodelos de acrilonitrilo butadieno estireno (ABS), producidos mediante impresión 3D, como injertos en tibias de conejos. Se utilizaron seis conejos de la raza Nueva Zelanda, en los cuales se implantaron dispositivos en forma de tornillos de 7 mm de longitud. Los implantes fueron esterilizados mediante autoclave o por inmersión en glutaraldehído. Los animales fueron evaluados clínicamente hasta el tercer día postoperatorio y radiográficamente a los 0, 30 y 60 días. Posteriormente, se realizó la eutanasia y la evaluación macroscópica de los implantes. El ABS presentó baja reactividad tisular, ausencia de rechazo y evidencias de osteointegración. Aunque la esterilización por autoclave causó una ligera deformación, no comprometió la implantación. Los resultados indican que el ABS tiene potencial para su aplicación en implantes ortopédicos personalizados, siendo necesarios estudios adicionales a largo plazo.

Palabras clave: Biomodelos. Conejos. Implantes óseos. Impresión 3D. Polímeros.

1 INTRODUCTION

The search for new technologies involving different materials and manufacturing processes has increasingly gained space in both scientific research and the market, whether in industry, communication, art, and more recently, in the healthcare field, with applications in surgical planning, prosthesis development, anatomy teaching, and implant production (SILVA; KAMINSKI, 2008). This technological advancement is directly related to the growing demand for greater precision, customization, and efficiency in both production and therapeutic processes (GIBSON; ROSEN; STUCKER, 2015).

In addition, there is an increasing concern regarding the development of sustainable technologies that minimize environmental impact and material waste. In this context, additive manufacturing stands out for using only the necessary amount of material during fabrication, unlike traditional subtractive methods (SALCHER et al., 2013; GEBHARDT, 2012). This characteristic makes it particularly attractive from both environmental and economic perspectives.

Additive manufacturing (AM), also known as rapid prototyping, comprises a group of technologies capable of producing three-dimensional objects through the successive deposition of material layers based on digital models (VOLPATO; CARVALHO, 2007; SANTOS et al., 2018). According to Gibson, Rosen, and Stucker (2015), this process allows a high degree of geometric freedom, enabling the fabrication of complex structures that would be difficult or impossible to achieve using conventional methods.

In addition to CAD-generated models, AM can also utilize data obtained from three-dimensional scanning techniques, such as computed tomography and laser scanning, within the framework of reverse engineering (RAULINO, 2011; CHUA; LEONG; LIM, 2010). This significantly expands its applications, particularly in the biomedical field, where customization is a critical factor for therapeutic success.

Three-dimensional printing technology eliminates the need for molds and specific tooling, reducing production steps and allowing direct fabrication of final products. Furthermore, the technology itself can generate support structures during the printing process, which are later removed, facilitating the construction of complex geometries (RAULINO, 2011; GEBHARDT, 2012).

Currently, several additive manufacturing systems are available on the market, all based on the same principle of layer-by-layer fabrication, but utilizing different materials such as polymers, metals, and ceramics. These systems were initially developed for industrial applications with the aim of reducing production time, improving quality, and lowering costs, and were later incorporated into the healthcare field (GIBSON; ROSEN; STUCKER, 2015).

In medicine, the use of additive manufacturing has revolutionized surgical planning by enabling the creation of three-dimensional anatomical models from imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) (LIMA, 2009). These models provide improved visualization of anatomical structures and support clinical decision-making (RENGIER et al., 2010).

Moreover, the conversion of medical imaging data into three-dimensional models allows the fabrication of highly accurate biomodels, contributing to the development of customized prostheses, surgical guides, and implants (MATOZINHOS et al., 2017; VENTOLA, 2014). These applications have demonstrated significant benefits, including reduced surgical time and improved clinical outcomes.

In veterinary medicine, the application of these technologies has also grown considerably, especially in orthopedics and traumatology. The use of biomodels enhances surgical planning and increases procedural predictability, contributing to better clinical outcomes (OSORIO et al., 2018).

With ongoing research advancements, new therapeutic possibilities are being explored, including the use of 3D printing for the production of biological structures and personalized devices. Some authors suggest that, in the future, it may be possible to fabricate tissues and organs using the patient's own cells, thereby reducing the risk of immune rejection (BARRETO et al., 2018; MURPHY; ATALA, 2014).

In terms of materials, polymers play a fundamental role in additive manufacturing. Natural polymers are those formed during the life cycle of living organisms (FRANCHETTI; MARCONATO, 2006), whereas biopolymers are derived from renewable resources such as corn, sugarcane, cellulose, and chitin (BRITO et al., 2011). These materials have been widely studied due to their biodegradability and reduced environmental impact.

Historically, humans have used natural polymers such as wool, leather, and natural rubber to produce everyday materials (BROWN et al., 2005). However, with industrial advancement, synthetic polymers have gained prominence due to their versatility and superior mechanical properties (CALLISTER; RETHWISCH, 2016).

Among synthetic polymers used in additive manufacturing, acrylonitrile butadiene styrene (ABS) stands out as a widely used thermoplastic due to its favorable mechanical and thermal properties. ABS exhibits high impact resistance, good dimensional stability, low moisture absorption, and ease of processing, making it suitable for use in fused deposition modeling (FDM) 3D printing (CHUA; LEONG; LIM, 2010; CALLISTER; RETHWISCH, 2016).

Furthermore, ABS presents characteristics that support its application in biomedical devices, such as adequate mechanical strength and the ability to be shaped into complex

structures. However, its biocompatibility remains under investigation, particularly for implantable applications (VENTOLA, 2014).

Given this context, it is essential to investigate the behavior of biomodels produced by additive manufacturing when implanted into biological tissues. Evaluating the biological response, including immune rejection and tissue integration, is crucial to determine the feasibility of these materials for clinical applications.

Thus, the present study aimed to evaluate the use of acrylonitrile butadiene styrene (ABS) biomodels produced by additive manufacturing as grafts in rabbit tibias, analyzing their biological resistance and immune response, with the perspective of future application in the development of easily accessible customized prostheses and orthoses.

2 METHODOLOGY

2.1 ETHICAL APPROVAL

This study was approved by the Animal Ethics Committee (CEUA) of the University of Rio Verde (UniRV) and conducted in accordance with the ethical principles established by the Brazilian College of Animal Experimentation (COBEA), under protocol number 09/21

2.2 ANIMALS

Six New Zealand rabbits (*Oryctolagus cuniculus*), approximately six months old and weighing around 3.5 kg, of both sexes, were used in this study. The animals were obtained from the rabbit breeding sector of UniRV and underwent a one-week acclimatization period, during which their general health status was monitored.

They were housed individually in cages under controlled environmental conditions, including adequate hygiene, temperature, lighting, and protection from weather conditions. Environmental enrichment was provided using hanging chains to minimize stress.

The animals were fed a commercial diet supplemented with carrot, hay, and kale, with water provided *ad libitum*. An 8-hour fasting period was implemented prior to the surgical procedure. After surgery, the animals were maintained under the same conditions for eight weeks.

2.3 IMPLANT FABRICATION

The implants were manufactured using a Zonestar DIY 802QR2 3D printer, equipped with dual extrusion nozzles with X–Y axis movement and a heated print bed with Z-axis movement.

The fused deposition modeling (FDM) technique was employed, using acrylonitrile butadiene styrene (ABS) filament. The implants were designed and printed in the form of screws measuring 7 mm in length.

2.4 IMPLANT STERILIZATION

Two sterilization methods were used. For the first group, implants were packaged in surgical-grade paper and sterilized in an autoclave at 160°C for 30 minutes.

For the second group, implants were immersed in glutaraldehyde solution for 8 hours. Prior to implantation, the materials were rinsed with sterile distilled water to minimize potential tissue toxicity.

2.5 PREOPERATIVE PROCEDURES AND ANESTHETIC PROTOCOL

After confirmation of clinical health status, animals underwent wide trichotomy in the medial metaphyseal region of both tibias, as well as in the auricular region for access to the caudal auricular vein. Body weight was recorded using a digital scale with 1g precision one day prior to surgery.

Animals were then referred to the surgical center of the Veterinary Hospital for Small Animals at UniRV.

The anesthetic protocol consisted of intramuscular administration of acepromazine (0.05 mL/kg), tramadol hydrochloride (3 mg/kg), midazolam (0.2 mg/kg), and ketamine (22 mg/kg), followed by local infiltrative anesthesia using 0.4 mL of 2% lidocaine.

During the procedure, animals were monitored continuously and received 100% oxygen via an oronasal mask. Anesthesia was maintained with isoflurane at an initial concentration of 2.5%, adjusted as needed.

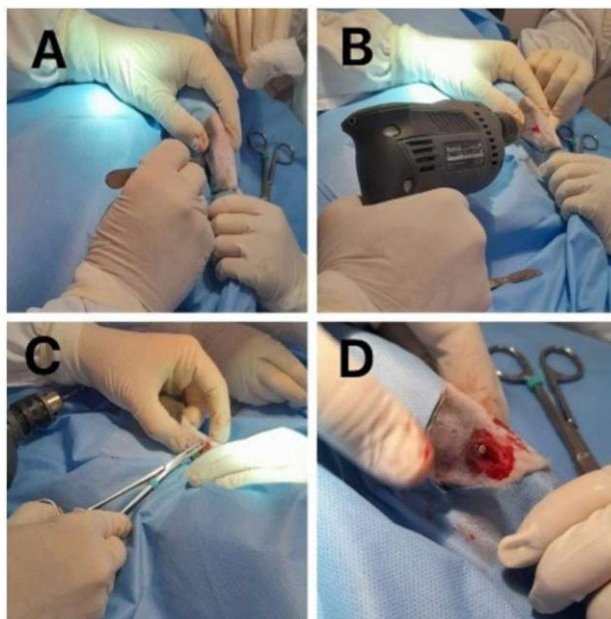
2.6 SURGICAL PROCEDURE

After achieving an adequate anesthetic plane (Guedel stage III, plane 3), antisepsis of the surgical site was performed using two applications of 2% chlorhexidine gluconate followed by 70% alcohol, and final antisepsis with three additional applications of 70% alcohol. The surgical field was then draped using sterile fenestrated drapes.

A skin incision of approximately 3 cm was made using a size 21 scalpel blade, followed by blunt dissection of the subcutaneous tissue using Metzenbaum scissors. A longitudinal incision was then made in the periosteum to expose the proximal medial metaphyseal cortex of the tibia (Figure 1).

Figure 1

A – Skin incision made with a scalpel. B – Bone drilling conducted with surgical drills. C – Implant placement with manual stabilization. D – Implant positioned and fixed in bone tissue.



Source: Prepared by the authors.

A bone perforation measuring 7 mm in depth and 2 mm in diameter was created using surgical drills under high-speed rotation with continuous irrigation using sterile saline solution.

The implants were manually inserted and stabilized using Kocher forceps. After implantation, muscular fascia was sutured using absorbable Vicryl 5-0, and the skin was closed using nylon 4-0. Implants placed in the right tibias were sterilized by autoclave, while those in the left tibias were sterilized using glutaraldehyde.

2.7 POSTOPERATIVE CARE

After surgery, the animals were monitored until full recovery from anesthesia and then returned to their housing.

Postoperative medication included enrofloxacin (5 mg/kg, once daily for 7 days), tramadol hydrochloride (3 mg/kg, three times daily for 3 days), and meloxicam (0.1 mg/kg, once daily for 4 days), all administered subcutaneously.

Surgical wounds were cleaned daily using sterile saline solution and treated with rifamycin spray. After the third postoperative day (D3), no further clinical alterations were observed, and handling was minimized to reduce stress.

2.8 CLINICAL EVALUATION

Implant sites were clinically evaluated up to the third postoperative day (D3). Edema was assessed using a binary scoring system: score 0 for absence of edema and score 1 for presence of edema

2.9 RADIOGRAPHIC EVALUATION

Pelvic limbs were evaluated radiographically every 30 days after surgery (D0, D30, and D60), totaling three evaluations per animal. Since radiographic findings were homogeneous across all treatments and replicates, statistical analysis was not performed for this parameter.

2.10 EUTHANASIA AND IMPLANT EVALUATION

After 60 days, animals were euthanized using an overdose of ketamine administered intravenously via the caudal auricular vein, followed by potassium chloride administration. Vital parameters, including heart rate, respiratory rate, and pulse, were monitored to confirm death. Following confirmation, tibias were collected and individually stored in 10% formalin for subsequent analysis

2.11 STATISTICAL ANALYSIS

A completely randomized design was used, with two treatments and six replicates. The treatments consisted of implant sterilization by autoclave or glutaraldehyde, and each animal represented one experimental unit. Data obtained were subjected to analysis of variance (ANOVA) using the F-test at a 5% significance level.

3 RESULTS AND DISCUSSION

The implants sterilized by autoclaving showed slight deformation when compared to the original printed prototypes. This finding represents a potential limitation, as one of the main advantages of additive manufacturing is the ability to produce customized implants with high dimensional accuracy. Despite this alteration, no difficulty was observed during implant insertion into the bone tissue.

Thermal sterilization methods, such as autoclaving, are known to affect the structural integrity of thermoplastic polymers, including acrylonitrile butadiene styrene (ABS), due to their sensitivity to high temperatures (GEBHARDT, 2012; CALLISTER; RETHWISCH, 2016). This may explain the observed deformation and highlights the importance of selecting appropriate sterilization techniques for polymer-based implants. In contrast, implants

sterilized using glutaraldehyde maintained their structural characteristics, suggesting that chemical sterilization may be more suitable for preserving the integrity of additively manufactured ABS components. The choice of sterilization method is a critical factor in determining the performance and biocompatibility of

implanted biomaterials (SEHLINGER et al., 2015).

Regarding clinical evaluation, although four out of six implants sterilized with glutaraldehyde presented edema at the incision site, no statistically significant difference was observed between the treatments at the 5% significance level. These findings suggest that both sterilization methods are comparable in terms of short-term inflammatory response.

Postoperative radiographic evaluations performed at 0, 30, and 60 days revealed homogeneous results among all animals, indicating consistent implant positioning and absence of apparent complications such as displacement or severe bone reaction. Radiographic analysis is widely recognized as an effective method for assessing bone healing and the performance of biomaterials in vivo (SILVA et al., 2003).

Macroscopic evaluation of the tibias after euthanasia demonstrated no evidence of implant rejection. Additionally, signs of osteointegration were observed in all animals, indicating a favorable biological response to the implanted material.

These results are consistent with previous studies that reported fibrovascular infiltration and good biocompatibility of polymer-based implants, supporting their use in reconstructive procedures (GOMES JÚNIOR et al., 2016). The absence of significant adverse reactions suggests that ABS may be considered a promising material for orthopedic applications, particularly when used in customized implants produced by additive manufacturing.

Furthermore, the low tissue reactivity observed in this study reinforces findings from previous research indicating that certain synthetic polymers can exhibit acceptable biological behavior when properly processed and sterilized (VENTOLA, 2014).

Taken together, the results demonstrate that additive manufacturing using ABS can produce implants with adequate mechanical and biological performance for experimental orthopedic applications. However, the choice of sterilization method plays a crucial role in maintaining implant integrity and should be carefully considered in future applications.

4 CONCLUSION

This study demonstrated that biomodels produced by additive manufacturing using acrylonitrile butadiene styrene (ABS) can be successfully applied as bone implants in rabbit tibias, showing satisfactory biological performance. The absence of rejection and the

presence of osteointegration indicate that ABS is a promising material for orthopedic applications.

Although autoclave sterilization caused slight deformation, it did not impair implantation or short-term outcomes. In contrast, glutaraldehyde preserved implant integrity, highlighting the importance of selecting appropriate sterilization methods for polymer-based biomaterials.

Overall, the findings support the feasibility of using ABS for the development of low-cost, customized implants. However, further studies are needed to evaluate long-term behavior and histological responses.

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CEMETERY: MORE HUMAN, INTELLIGENT, AND SUSTAINABLE

CEMITÉRIO: MAIS HUMANO, INTELIGENTE E SUSTENTÁVEL

CEMENTERIO: MÁS HUMANO, INTELIGENTE Y SOSTENIBLE



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ABSTRACT

This article discusses the main problems of traditional cemeteries in urban centers, including the lack of space due to population growth, environmental contamination from the use of toxic products in burials, public health issues arising from poor management and maintenance, and cultural and religious issues that make the grieving experience more challenging. The goal is to propose a new cemetery model integrated into urban planning that minimizes environmental impacts and offers a more humane experience for families and visitors, contributing to the sustainable development of cities. Additionally, this work highlights the importance of interdisciplinary research and partnerships between government, the private sector, and academia to develop this new cemetery paradigm. The method used was an integrative review on the subject. The article first addresses the current problems of traditional cemeteries; then, it introduces concepts of smart and sustainable cities that can be applied to cemeteries; and finally, it suggests the implementation of a new model for cemeteries, including the addition of green spaces, efficient use of water resources and solar energy, artificial intelligence-based monitoring systems, as well as virtual memorials and other innovations. Certainly, this innovative model has the potential to create a more humane and sustainable environment for urban cemeteries by integrating smart technologies and meeting the cultural and emotional needs of communities.

Keywords: Cemeteries. Smart Cities. Sustainability. Urban Problems. Urban Parks.

RESUMO

Este artigo discute os principais problemas dos cemitérios tradicionais em centros urbanos, incluindo a falta de espaço devido ao crescimento populacional, a contaminação ambiental decorrente do uso de produtos tóxicos nos sepultamentos, problemas de saúde pública provenientes da má gestão e manutenção, e questões culturais e religiosas que tornam a experiência do luto mais desafiadora. O objetivo é propor um novo modelo de cemitério integrado ao planejamento urbano que minimize os impactos ambientais e ofereça uma

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experiência mais humana para familiares e visitantes, contribuindo para o desenvolvimento sustentável das cidades. Além disso, este trabalho destaca a importância da pesquisa interdisciplinar e de parcerias entre governo, setor privado e academia para o desenvolvimento desse novo paradigma de cemitério. O método utilizado foi uma revisão integrativa sobre o tema. O artigo inicialmente aborda os problemas atuais dos cemitérios tradicionais; em seguida, apresenta conceitos de cidades inteligentes e sustentáveis que podem ser aplicados aos cemitérios; e, por fim, sugere a implementação de um novo modelo de cemitério, incluindo a incorporação de áreas verdes, uso eficiente de recursos hídricos e energia solar, sistemas de monitoramento baseados em inteligência artificial, bem como memoriais virtuais e outras inovações. Certamente, esse modelo inovador tem o potencial de criar um ambiente mais humano e sustentável para os cemitérios urbanos ao integrar tecnologias inteligentes e atender às necessidades culturais e emocionais das comunidades.

Palavras-chave: Cemitérios. Cidades Inteligentes. Sustentabilidade. Problemas Urbanos. Parques Urbanos.

RESUMEN

Este artículo discute los principales problemas de los cementerios tradicionales en los centros urbanos, incluyendo la falta de espacio debido al crecimiento poblacional, la contaminación ambiental derivada del uso de productos tóxicos en los entierros, problemas de salud pública provenientes de una gestión y mantenimiento deficientes, y cuestiones culturales y religiosas que hacen más desafiante la experiencia del duelo. El objetivo es proponer un nuevo modelo de cementerio integrado a la planificación urbana que minimice los impactos ambientales y ofrezca una experiencia más humana para familiares y visitantes, contribuyendo al desarrollo sostenible de las ciudades. Además, este trabajo destaca la importancia de la investigación interdisciplinaria y de las alianzas entre el gobierno, el sector privado y la academia para el desarrollo de este nuevo paradigma de cementerio. El método utilizado fue una revisión integradora sobre el tema. El artículo primero aborda los problemas actuales de los cementerios tradicionales; luego, presenta conceptos de ciudades inteligentes y sostenibles que pueden aplicarse a los cementerios; y finalmente, sugiere la implementación de un nuevo modelo de cementerio, incluyendo la incorporación de áreas verdes, el uso eficiente de los recursos hídricos y de la energía solar, sistemas de monitoreo basados en inteligencia artificial, así como memoriales virtuales y otras innovaciones. Sin duda, este modelo innovador tiene el potencial de crear un entorno más humano y sostenible para los cementerios urbanos al integrar tecnologías inteligentes y atender las necesidades culturales y emocionales de las comunidades.

Palabras clave: Cementerios. Cidades Inteligentes. Sostenibilidad. Problemas Urbanos. Parques Urbanos.

1 INTRODUCTION

It is not a recent issue that most cities face serious problems such as mobility, pollution, and informal settlements. Another concern involves traditional cemeteries, which, due to a lack of urban planning and a misguided development model, have exacerbated the situation in Brazilian municipalities. It is imperative that in the very near future, cities seek definitive solutions to address this pressing issue.

As [1] (p. 160) state, "Currently, we are experiencing a new moment of transformation in the way bodies are interred and in the methods of their disposal, triggered by population growth, urban expansion, and environmental contamination, the latter caused by byproducts of body decomposition."

In this present work, we intend to briefly address the main problems of traditional cemetery models in urban centers, which include: the lack of space, related to population growth and the limited availability of land for new graves; environmental pollution caused by cemeteries due to the use of embalming methods and burial techniques that can contaminate the soil with toxic substances, as well as groundwater contamination by pathogenic microorganisms resulting from body decomposition; public health problems that cemeteries can also cause through the spread of diseases and infections, especially if not properly maintained; the lack of maintenance that urban cemeteries often suffer from due to insufficient resources and personnel for their upkeep, which can lead to unsanitary and dangerous conditions; and finally, cultural and religious issues related to the burial of loved ones in traditional urban cemeteries, which can make the experience more difficult and traumatic for visitors.

The truth is that cemeteries have always been understudied and underdiscussed, and undoubtedly, they give rise to many other problems that certainly deserve investigation, from the economic devaluation of the surrounding land to public safety concerns.

Furthermore, the social relevance of these structures, which have also come under scrutiny due to declining visitation rates, changes in burial practices such as cremations, and questions about whether the space occupied by the cemetery is linked to a "perpetual care" obligation, often leads them to fall into disuse and abandonment [1].

After all, we are born, we grow, and we die... we are living beings, which is why cemeteries will always be useful and necessary. The challenge when addressing such a relevant topic is how we will transform the traditional cemetery model into a new model of cemeteries that are considered more humane, intelligent, and sustainable.

The research method employed is bibliographical and exploratory, based on a theoretical-conceptual perspective (literature reviews) on the subject.

Therefore, as the research objective, we aim to propose a model of urban, humanistic, and sustainable development to address the socio-environmental issues arising from the expansion of cities and urban agglomerations, guided by innovative factors for the implementation of human, intelligent, and sustainable cemeteries.

2 THEORETICAL FOUNDATION

2.1 CEMETERIES AND URBAN PROBLEMS

The truth is that the majority of traditional cemeteries, as currently designed with large graves, often create endless concrete mazes that people sometimes struggle to navigate when trying to locate the burial site of their loved ones. The lack of burial space is a recurring problem in crowded cemeteries in many Brazilian municipalities, but this is just the beginning.

Certainly, burial plots are limited and valuable. As a result, traditional cemeteries occupy a significant amount of space, which can be problematic in densely populated areas. In this context, the scarcity of land and extreme population density in Hong Kong are discussed by Yung and Chan as factors that create difficulties in accommodating new cemetery spaces in the city. Long-term planning becomes crucial in such scenarios [2].

The lack of burial space can limit cemetery expansion and eventually fill it up, forcing administrators to consider less desirable options, such as exhumation or the creation of new cemeteries in less suitable areas.

The concept of cemetery parks emerges as a way to reintegrate these spaces into the urban fabric of contemporary cities, overcoming the historical segregation of cemeteries [3].

Indeed, in large and medium-sized municipalities, the disorderly urbanization process is a common sight, with cemeteries often not integrated into the urban fabric, even in central areas, which can have various impacts, including emotional ones on the population.

In this regard, Lynch discusses the concepts of "legibility" and "imageability," that is, how easy it is for people to construct a clear mental image of the city and its elements. Lynch analyzes how cemeteries can be important elements in people's mental image of a particular city or neighborhood [4].

The author further explores the idea that cemeteries evoke a "vivid image" in people's minds, arousing emotions, memories, and meanings. This reinforces their unique power as distinctive elements in shaping the mental image of the city [4].

Thus, he classifies cemeteries as urban "landmarks," external reference points for the observer, which end up structuring their perception of the surroundings. Cemeteries often become landmarks due to their dimensions, symbolic importance, or simply visibility in the landscape [4].

Moreover, according to Lynch, some urban landmarks, such as squares and cemeteries, define "nodes" of activity and gatherings in the life of neighborhoods. In other words, they influence the flows and interactions of people in public spaces [4].

This makes urban planning and reorganization challenging, as there are still aspects related to property devaluation around cemeteries.

On the other hand, the importance of urban planning integrating the location and expansion of cemeteries in cities from the outset is emphasized. Neglecting this dimension leads to future problems [2].

Another focus is on public health problems, especially when cemeteries are not properly managed. For example, if bodies are not buried deep enough, animals can dig them up and spread diseases. Additionally, in some areas, cemeteries are prone to flooding, which can lead to water contamination, as was the case in Santa Catarina (Rain causes cemetery collapse, and mortuary chapels fall onto cars in the State of Santa Catarina/Brazil, 2022) [5].

Therefore, it is becoming increasingly difficult for municipal authorities to make decisions regarding urbanization in the face of constant and rapid population growth in urban centers, making a sustainable cemetery model essential.

Furthermore, the administrative and economic aspects cannot be ignored. The difficulty in maintaining cemeteries throughout Brazil must also be evaluated, as the costs associated with the maintenance and administration of traditional cemeteries can be significant.

Another point to consider is the issue of security. Many cemeteries today can be dangerous places, especially at night, which can be problematic for visitors and workers who need to access them. Additionally, there have been numerous cases of theft and vandalism reported in the media (Theft of crosses in Florianópolis cemetery becomes a police case) [6].

Jacobs highlights the concept of "eyes on the street" - the security provided by the informal presence and surveillance of residents, pedestrians, and users of public spaces. Better integrating cemeteries into adjacent areas could facilitate this community surveillance.

She emphasizes that the vitality of neighborhoods is associated with the sense of belonging and emotional attachment of local residents to public spaces. She ponders, "To what extent do a city's cemeteries evoke this attachment and constitute an emotional heritage of communities?" As a result, she believes that diversity of uses is essential to keep cities vibrant and safe. In this sense, there is a need to transform cemeteries into "living spaces" with various functions (culture, leisure), thus making these places more integrated and secure [7].

2.2 MORE HUMAN, INTELLIGENT, AND SUSTAINABLE CITIES

There is no doubt that municipal administrations must play a strategic role in seeking adequate solutions and responses to the local or global social challenges they face today. This is particularly challenging in the context of a post-pandemic crisis caused by Covid-19. Therefore, it is essential to seek efficiency in public management through public-private partnerships to address the issues related to traditional cemeteries, aiming for a new concept of a necropolis.

In this context, [8].draw attention to the strategic use of public contracts, which have a huge impact on the management of smart cities, as follows: "Government contracts and public procurement should include new agents and new formats to allow government products and services to be open source; this means incorporating elements of innovation focused on sustainability and inclusion into these procurement processes. Innovation contracts mean involving procurement departments in the procurement process to ensure that technologies (such as open-source software) can be obtained from reliable suppliers at lower costs and better quality, and that open standards and interoperability are implemented. Open-source software should be easily accessible to governments at all levels."

Therefore, it is necessary for the public administration to review the entirety of procurement processes to facilitate more efficient public spending, enabling innovation in both products and services and the profile of suppliers, with greater access to micro and small businesses.

For this reason, it is essential that the cities of the future do not develop according to the old paradigm of spatial segregation of everyday functions.

Regarding sustainability, the impact caused by the traditional burial process, which involves the use of wooden coffins, linings, pillows, and other accessories, can have a significant environmental impact. Additionally, many cemeteries lack infrastructure to collect and recycle generated waste.

Reference [9] says that to break with the traditional model, it is necessary to deconstruct the existing, rid oneself of concepts and prejudices, and seek a new path of innovation and sustainability. He asserts: "Inventions, innovations, technical, cultural, and ideological creations emerge and modify evolution. That is, they revolutionize it and henceforth make the principles of evolution evolve."

It is important to say that a "smart city" is one that utilizes human capital, creates new innovation ecosystems where work and wealth occur, promotes new forms of participation (governance), using technology as an enabler, while people are its actors. Furthermore, cities must be smarter and more efficient in solving the problems of rapid social urbanization [10].

Thus, as [10] put it, citizens are the driving force of change. Through their motivation and empowerment, significant challenges can be addressed, "not to change infrastructure or adopt new technologies, but to involve people in civic life."

Innovations and creations produce transgressions that can expand and potentiate trends, which can infiltrate the dominant trend and modify its orientation or replace it. In this sense, evolution, whether biological, sociological, or political, is never straightforward or regular. History does not project massively like the volume of a river. It germinates marginally and develops transgressively.

It is also essential to highlight the philosophical aspect that cemeteries can represent, demonstrating absolute equality among humans in their final resting place. Without economic, social, racial, religious, or any other distinctions; the absence of ostentation and questionable taste such as the construction of tombs and mausoleums. Creating an appropriate environment for moments of remembrance and longing, in a place that can be visited by children, eliminating the fear and trauma caused by conventional cemeteries; turning the burial ground into a beautiful natural garden, leveling everyone with green lawns simply identified by a granite headstone.

It is time to shift our attention to designing a better quality of life experience in our cities, as they should be flexible and responsive to the desires and needs of their citizens, using technology to assist us.

2.3 MORE HUMAN, INTELLIGENT, AND SUSTAINABLE CEMETERIES

Well then, the idea is to think about how to plan our future as a new society that has truly learned from the pandemic crisis and had the determination to address the world's situation in a holistic sense. In doing this planning, we need a new city - the city of the future, that is, "A More Human, Intelligent, and Sustainable City - CHIS" [10].

From a contemporary perspective, the model of a more human, intelligent, and sustainable cemetery must be urgently incorporated into cities to solve the complex problem described. To achieve this, it is necessary to transform in order to evolve.

By incorporating multiple uses and social functions, cemetery parks ensure more vitality, movement, security, and integration with urban life in the surroundings. These spaces also emphasize the landscape, contemplation, and biodiversity preservation aspects of cemeteries, bringing people closer to nature [3].

Furthermore, with a sustainable and ecological design, the suggested cemetery model will have a harmonious landscape with a predominance of nature, beauty, serenity, and respect,

suitable for moments of reflection. It is also distinguished by not allowing any type of construction above the surface in the burial area.

Thus, it includes open spaces, extensive tree canopies, and ground-level species, with a large garden featuring various species of wildflowers and endangered native trees.

In this sense, Juliane Queiroz discusses the transformation of traditional cemeteries into "cemetery parks," combining funeral use with leisure, culture, services, and nature contemplation [3].

Additionally, it incorporates water resource reuse, including rainwater; new sustainable lighting systems, such as solar energy capture through photovoltaic panels and LED lights; easy access to any point; outdoor benches, flower shops, snack bars, restaurants, modern restrooms, medical clinics, mortuary and ecumenical chapels, among other services.

Regarding solid waste, intelligent trash cans that notify when they need to be emptied or issue alerts (beeps) when the disposed material is not consistent with solid waste separation (plastics, glass, metal, organic material) are included.

Green areas will be suitable for walking or ecological trails, running tracks, and bike paths, all integrated and part of the concept of a smart cemetery. The cemetery will have a space with musical ambiance (Mother's Day, Father's Day, remembrance days, etc.), AI-based monitoring for visitor safety, a digital system with QR codes to locate the deceased's gravestone, directing visitors through maps to a virtual memorial with messages, images, and videos to remember their loved ones, all accessible via smartphones.

It is worth noting that, most of the time, technological solutions are not implemented due to high costs and accessibility issues. This justifies initiatives in ecosystems aimed at developing new technologies for the evolution of human, intelligent, and sustainable cemeteries in the context of smart cities.

As [8] rightly pointed out, "the Bahian intellectual who thought a lot about cities said: the world is made up not only of what already exists but also of what can effectively exist."

Regarding the concept of compact and vertical cemeteries, which can be explored in other urban contexts, it involves underground utilization and the better use of existing land to maximize capacity [2].

Thus, let's imagine a more human and intelligent cemetery permeated with sustainability, a space where people can breathe clean air, engage in their daily walking routine as if it were a park, with many native trees and green spaces.

This represents a different model from the current cemetery-park models, which still have a limited view of sustainability and innovation.

In the more human, intelligent, and sustainable cemetery, it will be possible to plant trees to honor loved ones, depositing their ashes to enrich the soil, as the biblical passage (Ecclesiastes 12:7 NLT) says, "from dust you came and to dust you will return."

For those who wish to be buried, the vertical burial method can be employed to occupy less space. Seeds can be released in capsules alongside eco-friendly coffins to grow trees that are on the brink of extinction. Consequently, we will have extensive green areas within urban areas.

In addition to these aspects, there will be psychological impacts associated with the implementation of intelligent cemeteries in vast green spaces, aiming to convey peace and tranquility to the location, and consequently, improve the acceptability of coexistence with urban proximity.

The conception of a new environmental education is necessary, based on a more humane and fraternal society, where everyone understands that we are part of cosmic dust and that we are only visitors on planet Earth.

Given the complexity of the problem involving religious aspects, it is necessary to understand that the proposed model of a more human and intelligent cemetery should continue to be a sacred place, and a sustainable religion should be fostered, respecting all beliefs.

It is also necessary to change cultural and religious paradigms about burials, making room for new options such as cremation, garden cemeteries, vertical columbariums, and it is essential to rethink rituals and traditions that may be crucial [2].

Furthermore, a new cemetery concept will bring interdisciplinary themes to the forefront, which must interact to make cities more human, intelligent, and sustainable, as [10] emphasizes: "Human intelligent cities propose the use of technology as a facilitator to connect and engage government and citizens, aiming to rebuild, recreate, and motivate urban communities, stimulating and supporting their collaborative activities, leading to an overall increase in social well-being."

To achieve this, the Table 1 below presents some results of theoretical references in the search for inspiration for an innovative model for a more human, intelligent, and sustainable scenario for urban cemeteries.

3 METHODOLOGICAL PROCEDURES

A methodology used for the present scientific work was an integrative literature review [11,12,13]. It is important to highlight that literature review is a fundamental first step in the

construction of scientific knowledge, as it is through this process that new theories emerge, and gaps and opportunities for research in a specific subject are recognized [13].

Therefore, the literature review process requires the development of a synthesis based on different topics, capable of creating a comprehensive understanding of knowledge. Additionally, it is worth noting that integrative reviews are the broadest type of review, as they allow for the simultaneous inclusion of both experimental and non-experimental research to gain a more comprehensive understanding of the phenomenon under investigation [11].

Reference [12] propose three stages for the integrative review: planning the review; conducting the review; and reporting and disseminating the review results.

Stage 1 - Planning the Review: The research began with identifying the need for the review and contextualizing the topic. The definition and contextualization of the theme delimits and particularizes its content, avoiding ambiguity that could lead to research focus deviation [13]. In the final phase of stage 1, the review protocol was constructed. The protocol is a plan that contributes to research objectivity through an explicit description of the steps followed [13].

Stage 2 - Conducting the Review: In this stage, the following were defined: search strategy; databases; time period; article languages; search terms; tools for data collection and organization; and inclusion and exclusion criteria. The search string ("cemeteries*" AND "urban problems" OR "urban planning AND "smart cities" AND "sustainability") underpinned searches in the Scopus database, which was selected for its broad document coverage. However, to increase reliability, the results were also cross-referenced with the Web of Science Core Collection and Ebsco to confirm the inclusion of all relevant studies. The search was performed by title, abstract, and keywords, resulting in a total of 272 results. In the databases, the following criteria for article inclusion and exclusion were applied: articles produced in the last 5 years (2018 to 2023), language: English, and document types: articles, totaling a pre-selection of 260 articles. In the next step, the title and abstract were read to identify adherence to the research topic and remove duplicate articles, thus selecting 21 articles for full reading. After reading, a synthesis matrix strategy was used for data extraction, which was used for the analysis and discussion of the results. The findings are included in Table 2. No discrepancies were found, confirming Scopus and Ebsco as the most comprehensive datasets. After several iterations and based on the research questions of the present study, the following search sequence was identified as the broadest and most effective for retrieving relevant articles.

Stage 3 - Reporting and Disseminating: The report was prepared based on the analysis and discussion of the results as presented below.

4 RESULTS AND DISCUSSION

This section presents the results obtained from the analysis and synthesis of the 21 articles related in Table I.

Table 1

Author	More humane, intelligent and sustainable cemeteries
[14]	An important consideration reported is about the location of cemeteries and their relative universality and permanence. Therefore, the issue of planning the location and design of cemeteries should be of special interest to the general public.
[15]	Public policies should ensure that legal standards are met in the construction of facilities to accommodate future burials, catering to all economic classes.
[16]	Article 25 of the Universal Declaration of Human Rights defines the right of everyone to "a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services." In this context, proper disposal can be interpreted as a necessary social service.
[17]	After recognizing the cultural, historical, and artistic importance of the cemetery, along with its natural value, "the main objective was to bring it back to public consciousness, introducing new forms of use. It's important to note that recreational and tourist use of

Author	More humane, intelligent and sustainable cemeteries
	cemeteries is partially interconnected because the green potential of a cemetery determines the interest in it (for example, visits for botanical value).
[18]	In Muslim cemeteries, for example, it is allowed to integrate cemeteries with recreational areas as long as their sanctity is preserved. There are limitations on recreational activities that can be conducted there, and only the area with severe land scarcity is authorized to do so.
[19]	The authors understand that there is an international body of evidence demonstrating the myriad roles of cemeteries beyond disposal and bodily remembrance. These roles include their value as recreational spaces similar to parks and for nature conservation.
[20]	Despite the purpose of cemeteries, it is necessary to consider that they often go beyond the need for a burial space to become a religious and sacred place for permanence and pilgrimage, as well as a place to demonstrate civic pride that also provides recreational amenities. Therefore, they have multiple social and political meanings, and their design holds significant cultural significance and provides insights into society and culture.
[21]	The author understands that gentrification and unaffordable property prices have led to

Author	More humane, intelligent and sustainable cemeteries
	issues such as urban expansion and the spread of informal settlements and slums in some cities. This is because those who cannot afford housing in certain areas opt for other forms of settlement that are considered relatively cheaper. This is especially true in cities where there is tangible evidence of resistance to adopting modern and technologically oriented solutions to address land scarcity in urban areas, which are seen as available in the contemporary notion of Smart Cities.
[22]	It is essential for society as a whole to understand sustainability as the primary alternative for production. Therefore, the resources taken from nature need to be used wisely. We can no longer consume just for the sake of consumption; a critical approach to our actions is necessary. In this way, it is crucial to comprehend the dimensions that sustainability presents in order to promote practices that are genuinely positive, including within cemeteries.
[23]	There are "green burial" sites where embalming is not allowed, and bodies are placed in coffins made of biodegradable materials such as willow or wrapped in a simple shroud.
[24]	The author explores some practical solutions that could be

Author	More humane, intelligent and sustainable cemeteries
	implemented to encourage green burials and how local governments can help make these greener options more accessible through permits, park fees, tax credits, mixed-use spaces, and the legalization of innovative options such as aquamation and human composting.
[25]	The author states that in the changing metropolitan landscape, cemeteries can become islands of biodiversity conservation. Due to their size, habitat heterogeneity, and continuity, cemeteries play a significant role in urban biodiversity conservation. Similarly, it's important to highlight that the educational and cultural value/role of cemeteries would be enhanced if special plants were "labeled" and animal habitats were marked. This would help promote the discovery and understanding of native and exotic plant and animal species.
[26]	For the authors, by establishing the provision of "safe, inclusive, and accessible green and public spaces" as a goal, Sustainable Development Goal 11, "Sustainable Cities and Communities," highlights the crucial role of green areas in environmental and socio-spatial justice in cities working towards sustainability.
[27]	For a long time, philosophical deliberations about the design of cemeteries

Author	More humane, intelligent and sustainable cemeteries
	suggested that they should be designed as parks or forested areas to promote contemplation of nature and direct thoughts towards death. Cemeteries are important for urban ecosystems.
[28]	Indeed, promoting the use of green urban cemeteries has great potential for citizens and a sustainable city
[29]	We can no longer overlook the importance of the contributions that urban forests make to cities and their inhabitants, highlighting the author's words that our urban forests face threats from issues such as rapid urbanization, climate change, and the spread of pests and diseases.

The aim of the synthesis was to identify themes that could address the question of what are the main problems of traditional cemeteries in urban centers. Data synthesis was operationalized with the assistance of thematic analysis proposed by [30]. Thematic analysis enabled the identification and coding of themes throughout the entire process of reading and analyzing the articles.

After the literature review, several differences were found regarding the cult of the dead, depending on each country and culture. However, what stands out are the numerous similarities in the problems faced by cemeteries in the studies presented.

Many of the issues raised in distant regions of the world resonate in the same way in our proposed study object, the cemeteries of Florianópolis. Among them, the lack of interest from public and private sectors in the final resting place of humans is particularly notable. In the debate between the city of the living and the city of the dead, the former is planned while the latter is ignored.

This attitude leads to the belief that the disposal of bodies of those who inhabit the Earth will occur naturally, as if a person, at the end of their life, would fall at the feet of a tree and decompose naturally into the earth.

The result of this literature review is clearly reflected in the problems that this lack of attention from authorities to the cemetery segment causes. The lack of attention is reflected in: cemeteries insufficient for the size of the population, overcrowded cemeteries, poorly maintained cemeteries, clandestine graves, difficulties in reconciling religion and human habitat for leisure, soil pollution from improper human disposal.

Throughout the world, there is a search for a more humane and sustainable model to enable the cemetery segment. New disposal possibilities, such as cremation, do not provide a solution to the problems raised. With the related problem of areas for new cemeteries, which are rare and increasingly limited green areas for the leisure of urban populations, could we solve both issues by transforming existing cemeteries into new green cemetery-parks?

This is the question we leave for possible new research and discussion.

Therefore, for a city to be more humane, it needs:

- Respect for Cultural and Religious Differences - The formation and administration of the cemetery should take into account the different religious beliefs and cultural traditions of the community; and
- Social Justice - It is important to ensure that the cemetery is accessible to all, regardless of socioeconomic status. Planning should include measures to prevent discrimination and ensure dignity in burial.

To be smarter:

- Integration of Recreation Areas - As seen in Muslim cemeteries, it is possible to integrate recreational areas without compromising the sanctity of the site. This may involve technology to keep areas separate or inform visitors; and
- Information Systems - An efficient management system that can be accessed digitally can facilitate the process of finding burial locations, understanding associated fees, and even visualizing genealogies.

To be sustainable, it needs:

- Eco-Friendly Burial - Implement areas where embalming is not allowed, and coffins are made of biodegradable materials, contributing to a smaller environmental impact;
- Ecosystem Preservation - The cemetery can be planned to preserve the local flora and fauna, acting as an urban green space, and finally,
- Resource Management - Use solar energy for site maintenance, rainwater harvesting systems for irrigation, among other energy efficiency measures.

These are just starting points and can be expanded with more research and detailed planning. The ultimate goal should be to create a space that honors the deceased, meets the needs of the living, and minimizes the impact on the planet.

5 FINAL REMARKS

We are witnessing an unprecedented digital expansion that has the potential to influence even the most traditional and entrenched aspects of urbanization, such as cemeteries. The sustainability of these places, in times of accelerated change, becomes an urgent issue.

In this new scenario, the reinvention of cemeteries plays a fundamental role in the creation of smart cities. The harmonious integration of cemeteries with the surrounding urban fabric is not only a matter of space but also an opportunity to create more humane and relevant environments that truly contribute to the quality of life of citizens.

Proposals for smart cemeteries emphasize a convergence between urban green spaces, citizens, environmental sustainability, and technological advancements. These are environments designed to promote sustainable coexistence, with projects that incorporate ecology and adaptive and responsive technological systems. The goal is collaborative urbanism that envisions not only a better quality of life but also a more dignified and harmonious transition towards the end of life. Ultimately, the challenge is to design cities and cemeteries that are for the living as well as for those who have departed, reflecting our capacity for adaptation, resilience, and humanity in the face of contemporary challenges.

Thus, the literature review has shown that traditional cemeteries face various problems, such as lack of space due to population growth, environmental contamination from the use of toxic products, public health issues due to poor management, among other concerns.

In this light, a new model of cemeteries integrated into urban planning has been proposed, based on the concepts of sustainability, smart cities, and urban parks. The suggested model features characteristics such as green areas, resource reuse, solar energy, AI-based monitoring systems, virtual memorials, among other innovations.

Certainly, the scope is to minimize environmental impacts, offer a more humane experience to visitors, and contribute to the sustainable development of cities by transforming traditional models into smart and sustainable cemeteries. The implementation of this new paradigm requires interdisciplinary research and partnerships between the government, private sector, and academia. There are opportunities to develop innovative technological solutions and integrate them into urban planning.

Therefore, this article emphasizes the importance of reviewing public procurement processes to facilitate the acquisition of sustainable technologies and the participation of new actors, such as startups and entrepreneurs.

In conclusion, a change in mindset and the incorporation of concepts such as sustainability, innovation, and respect for nature are necessary for cemeteries to become more humane and integrated spaces within cities.

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PHYTOCHEMICAL ANALYSIS AND ICP-OES NUTRIMENTAL CONTENT IN EXTRACTS OF CASTOR-OIL PLANT (*R. COMMUNIS*), SWEET ACACIA (*V. FARNESIANA*) AND PINK GRASS (*R. REPENS*)

ANÁLISE FITOQUÍMICA E CONTEÚDO NUTRICIONAL POR ICP-OES EM EXTRATOS DE MAMONA (*R. COMMUNIS*), ACÁCIA-DOCE (*V. FARNESIANA*) E CAPIM-ROSA (*R. REPENS*)

ANÁLISIS FITOQUÍMICO Y CONTENIDO NUTRIMENTAL POR ICP-OES EN EXTRACTOS DE RICINO (*R. COMMUNIS*), ACACIA DULCE (*V. FARNESIANA*) Y PASTO ROSADO (*R. REPENS*)



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ABSTRACT

In the present investigation, several specialized secondary metabolites were extracted and identified to combat entomological pests and the nutritional aspects of three plant species were analyzed. Three wild plants were evaluated: castor-oil plant (*Ricinus communis*), sweet acacia (*Vachellia farnesiana*) and pink grass (*Rhynchelytrum repens*). The pure extracts were evaluated with the following specialized secondary metabolites analysis: flavonoids, sterols, triterpenes, phenols, quinones, saponins, catechins, tannins, triterpenes and anthocyanins. Macronutrient and micronutrient analyses of the extracts of the three plants extracts of castor-oil plant (*Ricinus communis*), sweet acacia (*Vachellia farnesiana*) and pink grass (*Rhynchelytrum repens*) were evaluated with the following methods. The Dumas method was used to analyze the percentage of nitrogen (w/w); the microwave ICP-OES (Inductively Coupled Plasma/Optical Emission Spectrophotometer) method was used to analyze the percentages of macronutrients in percentage (w/w) of phosphorus, potassium, calcium, magnesium, sulfur and sodium (mg/kg) and the percentage of chlorine with silver nitrate/argentometry. Micronutrient analyses of plant extracts were evaluated by microwave digestion/ICP-OES digestion in mg/kg of iron, zinc, manganese, copper, boron, nickel and molybdenum.

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Keywords: Specialized Secondary Metabolites. Plant-Metabolite-Insect. Nutriment Quality

RESUMO

Na presente investigação, vários metabólitos secundários especializados foram extraídos e identificados para combater pragas entomológicas, e os aspectos nutricionais de três espécies de plantas foram analisados. Três plantas silvestres foram avaliadas: higuierilla (*Ricinus communis*), huizache (*Vachellia farnesiana*) e capim-rosa (*Rhynchelytrum repens*). Os extratos puros foram avaliados com a seguinte análise de metabólitos secundários especializados: flavonóides, esteróis, triterpenos, fenóis, quinonas, saponinas, catequinas, taninos, triterpenos e antocianinas. As análises de macronutrientes e micronutrientes dos extratos das três plantas higuierilla (*Ricinus communis*), huizache (*Vachellia farnesiana*) e capim-rosa (*Rhynchelytrum repens*) foram avaliadas com os seguintes métodos. O método de Dumas foi utilizado para analisar a porcentagem de nitrogênio (p/p); o método ICP-OES (Espectrofotômetro de Emissão Óptica/Plasma Acoplado Indutivamente) por micro-ondas foi utilizado para analisar as porcentagens de macronutrientes em porcentagem (p/p) de fósforo, potássio, cálcio, magnésio, enxofre e sódio (mg/kg) e a porcentagem de cloro com nitrato de prata/argentometria. As análises de micronutrientes dos extratos vegetais foram avaliadas por digestão por micro-ondas/digestão ICP-OES em mg/kg de ferro, zinco, manganês, cobre, boro, níquel e molibdênio.

Palavras-chave: Metabólitos Secundários Especializados. Metabólitos Vegetais-Insetos. Qualidade dos Nutrientes

RESUMEN

En la presente investigación se extrajeron e identificaron varios metabolitos secundarios especializados para combatir plagas entomológicas y se analizaron los aspectos nutricionales de tres especies vegetales. Se evaluaron tres plantas silvestres: la higuierilla (*Ricinus communis*), el huizache (*Vachellia farnesiana*) y la hierba rosa (*Rhynchelytrum repens*). Los extractos puros se evaluaron mediante el análisis de los siguientes metabolitos secundarios especializados: flavonoides, esteroides, triterpenos, fenoles, quinonas, saponinas, catequinas, taninos, triterpenos y antocianinas. Los análisis de macronutrientes y micronutrientes de los extractos de las tres plantas —higuierilla (*Ricinus communis*), huizache (*Vachellia farnesiana*) y hierba rosa (*Rhynchelytrum repens*)— se evaluaron con los siguientes métodos. Se utilizó el método de Dumas para analizar el porcentaje de nitrógeno (p/p); el método ICP-OES (plasma acoplado inductivamente/espectrofotómetro de emisión óptica) por microondas se utilizó para analizar los porcentajes de macronutrientes en porcentaje (p/p) de fósforo, potasio, calcio, magnesio, azufre y sodio (mg/kg) y el porcentaje de cloro con nitrato de plata/argentometría. Los análisis de micronutrientes de los extractos vegetales se evaluaron mediante digestión por microondas/ICP-OES en mg/kg de hierro, zinc, manganeso, cobre, boro, níquel y molibdeno.

Palabras clave: Metabolitos Secundarios Especializados. Interacción Planta-Metabolito-Insecto. Calidad de los Nutrientes

1 INTRODUCTION

Secondary metabolites play an important role in protecting plants against various environmental stresses and insect pest emergence [1]. It has been estimated that approximately 100,000 secondary metabolites have been described in different plant species and are classified into multiple groups, nitrogen-containing compounds, terpenes, thiols, and phenolic compounds [2]. Focusing on the new model of plant-metabolite-insect interactions may represent a useful approach to find a new generation of organic bioinsecticides. Indeed, plants produce allelochemicals such as phenolic compounds, alkaloids and terpenoids targeting the behavior and physiology of hexapod arthropods. Thus, several compounds belonging to the above chemical classes may represent ideal ingredients for developing sustainable integrated pest and vector management programs. Minimal research has been conducted on nutritional and phytochemical analysis as well as biological evaluation of secondary metabolites of plant origin. Badaleменти et al. (2022) carried out work on the isolation and structural elucidation of several bufadienolides from *Drimia panchratium* and evaluated their acaricidal activity against a serious agricultural pest, *Drimia panchratium*, the two-spotted spider mite, *Tetranychus urticae* [3]. Regarding the lethal and sublethal effects of plant-based insecticides and acaricides, Ebadollahi et al. (2022) evaluated the efficacy of some essential oils of *Thymus* species against the stored-produce beetle *Rhyzopertha dominica* [4]. On the other hand, Changbunjong et al. (2022) investigated the fumigant activities and contact toxicity of bitter orange (*Citrus aurantium*) essential oil against the stable fly *Stomoxys calcitrans* [5]. Plata-Rueda et al. (2021) studied the sensitivity and behavioral response of the mealworm *Tenebrio molitor* to oregano (*Origanum vulgare*) essential oil [6]. Walker, (2020) tested three Apiaceae essential oils, namely anise (*Pimpinella anisum*), dill (*Anethum graveolens*) and fennel (*Foeniculum vulgare*) against *Lymantria dispar*, showing them as potential agents for gypsy moth control [7]. Song and Zhou (2020), highlighted the promising toxicity of essential oils extracted from plant species from Chilean Patagonia and Cameroon against agricultural (*Spodoptera littoralis*) and public health (*Culex quinquefasciatus* and *Musca domestica*) insects [8]. On the other hand, color pigmentation patterns can be indicative of cuticular damage in the exoskeleton of insects of the order Odonata [9]. Therefore, in the present investigation, several special secondary metabolites were extracted and identified to combat entomological pests, and the nutritional aspects of three plant species were analyzed. The objectives of this research are to analyze the content of secondary metabolites by phytochemical analysis and the nutritional content of the extracts of higuierilla (*Ricinus communis*), huizache (*Vachellia farnesiana*) and pink grass (*Rhynchelytrum repens*).

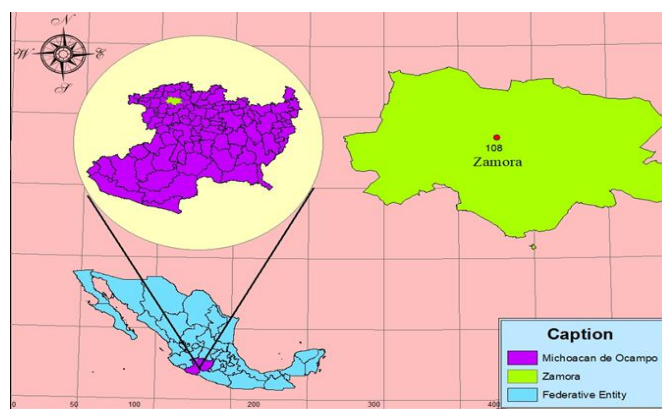
2 MATERIAL AND METHODS

2.1 COLLECTION OF BIOLOGICAL MATERIAL

Three types of wild plants were collected: higuierilla (*Ricinus communis*), huizache (*Vachellia farnesiana*) and pink grass (*Rhynchelytrum repens*) pathogen- and disease-free in Zamora, Michoacan, Mexico (Figure 1-2).

Figure 1

Biological sample collection area used in this project. Geographical coordinates: North Latitude: 20°04'32.99.99" and West Latitude 102°16'19.39"



Source: Authors (2025).

Figure 2

*Biological sample collection. (a) Phenotype aspect of higuierilla (*Ricinus communis*), (b) Phenotype aspect of huizache (*Vachellia farnesiana*) and (c) phenotype aspect of pink grass (*Rhynchelytrum repens*) in Zamora, Michoacan, Mexico*



Source: Authors (2025).

2.2 DRYING OF PLANT MATERIAL

The biological samples of higuierilla (*Ricinus communis*), b) huizache (*Vachellia farnesiana*) and c) pink grass (*Rhynchelytrum repens*) were dried on newspaper for 10 days and then in a drying oven (mod. Novatech) for 72 hours at 34 oC with the objective of dehydration in

order to obtain the extracts for secondary metabolite analysis. The analyses were performed in triplicate.

2.3 PHYTOCHEMISTRY ANALYSIS

2.3.1 Flavonoids analyses

Ammonia method. 0.1 g of each plant was weighed in triplicate in an analytical balance (brand). To obtain crude extracts, 10 ml of ethyl alcohol was added and allowed to stand for 30 min. After this period of time, to obtain pure extracts, the plant samples were filtered with Whatman filter paper no. 1, 3 ml of ammonia (NH₃) was added [10].

Alkali action. 0.1 g of each plant was weighed in triplicate in an analytical balance (brand). To obtain crude extracts, 5 ml of distilled water was added and allowed to stand for 30 min. After this period of time, to obtain pure extracts, the plant samples were filtered with Whatman filter paper no. 1, 3 ml of sodium hydroxide (NaOH) was added [11].

Shinoda reaction with the magnesium method. Pure extracts consisting of 5 ml of ethanol and 5 ml of methanol were prepared. 0.5 g of powder of each biological sample was weighed. The crude extract was allowed to stand for 30 min. After 30 min, 3 ml of the pure extract was placed in each test tube to add 0.1 g of magnesium filings and 3 drops of hydrochloric acid (HCl). The test is positive if the extract shows bubbling and turns orange. Shinoda assay this is used for flavonoids with a benzopyrone core in their structure, such as flavones, flavonols benzopyrone nucleus such as flavones, flavonols, flavanones, etc. produce reddish colorations when in aqueous or alcoholic solutions. aqueous or alcoholic solutions.

Sterols and triterpenes with the Salkowski method. Pure aqueous extracts were used. 1 ml of sulfuric acid (H₂SO₄) was added, the test is positive if the extract turns red or yellow for the detection of sterols or methylsterols.

Phenol detection with the ferric chloride method. 1.25 grams of ferric chloride (FeCl₃) was weighed. It was diluted in 8.75 ml of distilled water. It was left to rest for 30 minutes. It was filtered after 30 minutes and 3 drops of ferric chloride solution were added to the pure aqueous extract. The test is positive if the transition of the vire is from dark green to indigo blue is the presence of phenols; if it is full blue it is hydrolyzable tannins and if it turns dark green it is condensed tannins.

Quinones with the methanol and ethanol method. Pure leaf extracts were prepared. 0.5 g of powder of each leaf was rested, 5 ml of distilled water and 5 ml of methanol were added. The sample was filtered and allowed to stand. After 30 min, 1 ml of sulfuric acid (H₂SO₄) was added. If the extract turns red, the test is positive for the presence of quinones.

Saponins with the foam method. Pure methanol extracts were made from a) higuerilla (*R. communis*), b) huizache (*V. farnesiana*) and c) pink grass (*R. repens*). We weighed 0.5 g of powder from each plant, added 5 ml of methanol and left to stand for 30 minutes. After 30 minutes, 1 ml of pure extract was added followed by the addition of 9 ml of distilled water, each sample was placed in a screw cap test tube [12]. The tube was shaken vigorously by hand and allowed to stand for 15 minutes. The results are interpreted as follows:

Table 1

Interpretation of the volume of saponin foam

Foam area	Interpretation
<i>Foam formation greater than 15 mm</i>	<i>High content of saponins: test is positive</i>
<i>Foam formation between 5 to 10 mm</i>	<i>Moderate saponin content: test is positive</i>
<i>Foaming less than 5 mm</i>	<i>Less than 5 mm the test is negative: there is no presence of saponins.</i>

Catechin compounds with the formaldehyde method. Pure alcoholic extracts were prepared. We weighed 0.5 g of leaves and added 5 ml of ethanol and 5 ml of methanol. It was left to stand for 30 min. It was filtered to obtain the pure extract. Then, 5 ml of formaldehyde was added, followed by the addition of 10 drops of hydrochloric acid (HCl). Subsequently, a water bath device was placed. The formation of a precipitate reflects the content of a cationic tannin; the presence of spots or floating compounds reflects the presence of pyrogalllic tannins.

Tannins with the grenetin method. A 1% solution of grenetin was prepared in distilled water. Subsequently, 10 ml of the prepared grenetin solution was added in a test tube and 10 ml of sodium chloride (NaCl) was added over the pure aqueous extract (5 ml). The test is positive with the presence of a precipitate [12].

Triterpenes with the chloroform method. Pure ethanolic leaf extracts were made. 0.5 g of powder of each extract was weighed. Five ml of ethanol was added and left to stand for 30 minutes. After 30 min, the crude extract was filtered to obtain the pure extract. 1 ml of chloroform was added. 1 ml of acetic anhydride was added. The extracts were rested on ice and 2 drops of sulfuric acid (H₂SO₄) were added to each test tube. The test is positive if the pure extract turns pink, green, red, blue or purple [12].

Anthocyanins with the isoamyl alcohol method. Crude extracts were prepared with 5 ml ethanol and 5 ml methanol. It was rested for 30 minutes. The solution was filtered to obtain the pure extract. 5 ml of the pure extract was taken and transferred to test tubes. If the pure extract

turns red it is presence of anthocyanins, but if the alcoholic layer does not turn red it is presence of betacyanin.

2.4 NUTRIENT CONTENT

Dumas method was used to analyze the percentage of nitrogen (w/w). The Dumas combustion method is a comprehensive method for determining the total nitrogen content in a usually organic matrix. The Dumas method is based on the principle of destruction of organic matter through combustion under controlled oxygen supply at very high temperatures [13]. A combustion was generated, where the plant sample was incinerated at 900°C in the presence of oxygen. Then, a reduction was generated, where the nitric oxide produced by the combustion was reduced by tungsten to molecular nitrogen. This was followed by a purification stage, where a series of suitable sorbents (silver wool and tungsten) removed interfering constituents such as hydrogen halides and sulfur oxides from the gas mixture stream. The resulting water vapor was condensed and retained by a desiccant agent (phosphorus pentoxide), subsequent to the reduction process, where fine drying proceeds. Finally, nitrogen detection is performed with a thermal conductivity detector which measures the total nitrogen remaining in a carrier gas flow. The Dumas method is a closed system (the operator is not exposed to it) and does not use acids such as sulfuric acid (H₂SO₄), therefore it does not produce hazardous waste and has no operational risks for personnel (Cruz et al. 2007).

Microwave digestion/ICP-OES. Method was used to analyze the percentages of macronutrients and micronutrients. It was carried out by applying microwave waves at elevated temperatures using acid solutions of 10 ml of nitric acid (HNO₃) that serve the function of digesting the organic samples for subsequent analysis (Hackett et al., 2008). Subsequently, the digester tubes were closed and brought into the microwave oven, the equipment was set to a ramp temperature of 200 °C for 15 minutes. The temperature was maintained at 200 °C for approximately 20 minutes and then brought to room temperature for 10 minutes. Once digested, type 1 water was added to the residue and the residue was volumed to 50 ml in another tube for each sample. Once the previous step was completed, the residue was placed in the corresponding tubes for the ICP-OES equipment and filtered if necessary. The total time of digestion lasted 45 minutes a final volume of 50 ml with Water type 1 was used.

Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) conditions. The gas pressure was 100 psi Argon and 100 psi Nitrogen. The flow rate of the gases was: auxiliary gas 0.5 L/min y nebulizer gas 0.5 L/min. The speed of the peristaltic pump: 50 rpm. The reading was carried out for macroelements and microelements.

2.5 STATISTICAL ANALYSIS

For the statistical analysis, the statistical software R studio, version 4.2.2 (2022-10-31) was used. For the specific performance of the principal component analysis, the "FactoMineR" library or package of functions was used; within the same package, the PCA function was used to obtain the "Eigenvalues" or components that summarize the data matrix.

3 RESULTS AND DISCUSSION

3.1 PHYTOCHEMISTRY ANALYSIS

Pohlan et al. (2006), mention that pests are among the most important limiting factors in the productivity of important limiting factors in the productivity of agroforestry systems. These same researchers point out that insect pests are the organisms responsible for 37 to 50% of the are the organisms responsible for 37 to 50% of the losses reported in agroforestry reported in agroforestry worldwide [14]. Brechelt (2004), describes the concept assigned to the term "pest" as follows when an animal, a plant or a microorganism increases its density to abnormal levels and, as a consequence, affects directly or indirectly the human species, either because it harms their health, their comfort, damage to buildings or agricultural, forestry or livestock properties, of which they are or livestock, from which the human being obtains food, fodder, textiles, wood, timber, products, etc. [15].

Qualitative chemical analysis contains relatively simple colorimetric procedures based on chemical transformations with the creation of specific chromophores. The current understanding of plant-insect interaction has had profound consequences in the field of green chemistry research, particularly for its future prospects for the development of new plant-based biorational pesticides [16]. These interactions involve numerous secondary metabolites that may interfere with insect behavior, growth, development or reproduction. The evaluation of the potential bioactivity of natural products against these biological systems is considered of interest, in particular because of the diversity of the hydrocarbon skeletons and the complexity of their functions present in plants [17]. Table 2 shows the results obtained from the extracts of higuerilla (*R. communis*), huizache (*V. farnesiana*) and pink grass (*R. repens*).

Table 2

Results obtained from the phytochemical analysis of the extracts derived from higuierilla (*R. communis*), huizache (*V. farnesiana*) and pink grass (*R. repens*). **F: Flavonoids; S-T: Sterols and triterpenes; PC: Phenolic compounds; Q: Quinones; S: Saponins; C: Catechins; T: Tannins; TR: Triterpenes; A: Anthocyanins**

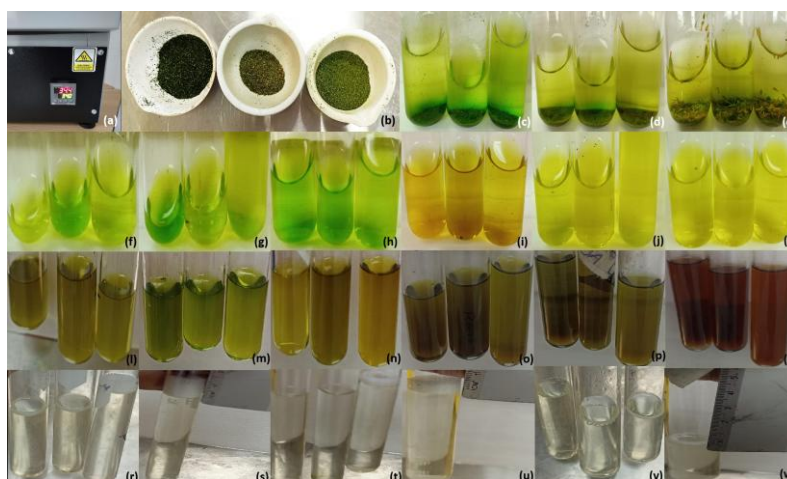
Extract type	Secondary metabolite	Assay	Results
<i>R. communis</i>	F	Ammonia	+ (chalcones and aurones)
<i>V. farnesiana</i>	F	Ammonia	+ (flavons and flavonols)
<i>R. repens</i>	F	Ammonia	+ (flavons and flavonols)
<i>R. communis</i>	F	Alkali action	+ (flavonols)
<i>V. farnesiana</i>	F	Alkali action	-
<i>R. repens</i>	F	Alkali action	+ (flavonols)
<i>R. communis</i>	F	Shinoda reaction	-
<i>V. farnesiana</i>	F	Shinoda reaction	-
<i>R. repens</i>	F	Shinoda reaction	+
<i>R. communis</i>	S-T	Salkowski reaction	+ (sterols)
<i>V. farnesiana</i>	S-T	Salkowski reaction	+ (sterols)
<i>R. repens</i>	S-T	Salkowski reaction	+ (methylsterols)
<i>R. communis</i>	PC	Ferric chloride	+ (Condensed tannins)
<i>V. farnesiana</i>	PC	Ferric chloride	+ (Condensed tannins)
<i>R. repens</i>	PC	Ferric chloride	+ to phenols
<i>R. communis</i>	Q	Methanol and ethanol	- (there was only a color change)
<i>V. farnesiana</i>	Q	Methanol and ethanol	- (there was only a color change)
<i>R. repens</i>	Q	Methanol and ethanol	- (there was only a color change)
<i>R. communis</i>	S	Foam method	+
<i>V. farnesiana</i>	S	Foam method	+
<i>R. repens</i>	S	Foam method	-

<i>R. communis</i>	C	Formaldehyde	- (there was only a color change)
<i>V. farnesiana</i>	C	Formaldehyde	- (there was only a color change)
<i>R. repens</i>	C	Formaldehyde	- (there was only a color change)
<i>R. communis</i>	T	Grenetin	- (absence of precipitate, but if there was color change)
<i>V. farnesiana</i>	T	Grenetin	- (absence of precipitate, but if there was color change)
<i>R. repens</i>	T	Grenetin	- (absence of precipitate, but if there was color change)
<i>R. communis</i>	TR	Chloroform method	+
<i>V. farnesiana</i>	TR	Chloroform method	+
<i>R. repens</i>	TR	Chloroform method	+
<i>R. communis</i>	A	Isoamyl alcohol method	-
<i>V. farnesiana</i>	A	Isoamyl alcohol method	-
<i>R. repens</i>	A	Isoamyl alcohol method	-

Figure 3 and Figure 4 shows the results of the positive presence of secondary metabolites in the phytochemical analyses.

Figure 3

Extraction process and identification of secondary metabolites in biological samples of higuierilla (*Ricinus communis*), huizache (*Vachellia farnesiana*) and pink grass (*Rhynchelytrum repens*). a) drying oven (mod. Novatech); b) pulverization of plant samples; c) crude extract of *R. communis*; d) crude extract of *V. farnesiana*; e) crude extract of *R. repens*; f) pure extract of *R. communis*; g) pure extract of *V. farnesiana*; h) pure extract of *R. repens*; i) pure extract of *R. communis* positive for flavonoids. repens; f) pure extract of *R. communis*; g) pure extract of *V. farnesiana*; h) pure extract of *R. repens*; i) pure extract of *R. communis* positive for flavonoids with NH_3 : chalcones and aurones; j) pure extract of *V. farnesiana* positive for flavonoids with NH_3 : flavones and flavonols; k) pure extract of *R. repens* positive for flavonoids with NH_3 : flavones and flavonols; l) extract of *R. communis* positive for flavonoids with NaOH : flavonols; m) pure extract of *V. farnesiana* negative for flavonoids with NaOH ; n) pure extract of *R. repens* positive for flavonoids with NaOH : flavonols; o) pure extract of *R. communis* negative for Shinoda reaction; p) pure extract of *V. farnesiana* negative for Shinoda reaction; q) pure extract of *R. rapens* positive for Shinoda reaction; r) pure extract of *R. communis* positive for saponins; s) positive evidence of foam in *R. communis*; t) pure extract of *V. farnesiana* positive for saponins; u) positive evidence of foam in *V. farnesiana*; v) pure extract of *R. repens* negative for saponins; and w) negative evidence of foam in *R. repens*



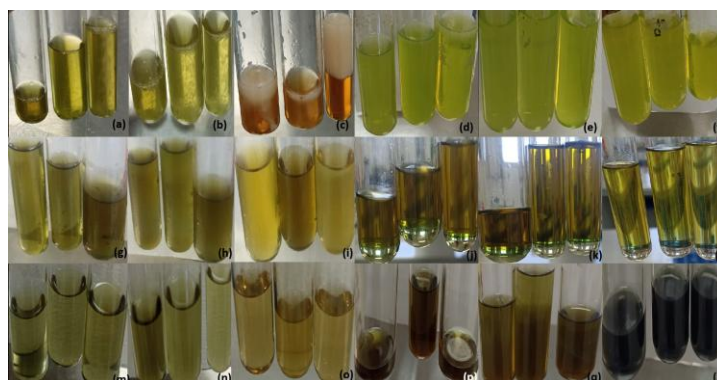
Source: Authors (2025).

An interesting group of secondary metabolites of higher plants are the flavonoid pigments, which are extremely abundant and variable in the degree of oxidation. For this class of compounds a large number of activities have been reported, such as antitumor, antihypertensive, anti-inflammatory, bactericidal, bactericidal, anti-inflammatory, anti-inflammatory, bactericidal or cell stabilizing. Against insects, it has been proved that they have insecticidal activity and growth inhibitory activity, and have been evaluated against a large

number of species, among them *Heliothis virescens*, *Spodoptera exigua*, *Heliothis zea*, *Manduca sexta*, *Amyelosis transitella*, *Ostrinia nubilalis* Hubner, and *Pieris brassicae*. Among the flavonoids that affect development and growth are quercetin, rutin, naringenin, rnaicin, eriodictyol and catechin [18-19].

Figure 4

Extraction process and identification of secondary metabolites in biological samples of higuerilla (Ricinus communis), huizache (Vachellia farnesiana) and pink grass (Rhynchelytrum repens). a) pure extract of R. communis negative for shinoda reaction; B) pure extract of V. farnesiana negative for shinoda reaction; C) pure extract of R. repens negative for shinoda reaction; D) pure extract of R. repens positive for shinoda reaction; D) pure R. communis extract negative for tannin reaction; e) pure V. farnesiana extract negative for tannin reaction; f) pure R. repens extract negative for tannin reaction; g) pure R. communis extract positive for triterpenes reaction; h) pure V. farnesiana positive for triterpenes reaction; i) pure extract of R. repens positive for triterpenes reaction; J) pure extract of R. communis positive for phenols reaction; k) pure extract of V. farnesiana positive for phenols reaction; l) pure extract of R. repens positive for phenols reaction; M) pure extract of R. communis negative for catechin reaction; n) pure extract of V. farnesiana negative for catechin reaction; o) pure extract of R. repens negative for catechin reaction; P) pure extract of R. communis negative for quinone reaction; q) pure extract of V. farnesiana negative for quinone reaction; and r) pure extract of R. repens negative for quinone reaction



Source: Authors (2025).

Flavonoids are important for host recognition and acceptance by adult insects. When an adult female butterfly or moth lands on a plant, she usually walks on the surface of the leaf or stem. The duration of this walk and the onset of the next behavior may depend on the stimuli received from the compounds on the plant surface. Some species start drumming with their forelegs upon contact with a potential contact with a potential host, others lower their antennae.

At least two factors support the claim that flavonoids play a role in insect-plant interactions. At firstly, that flavonoids can modulate insect feeding and oviposition behavior of insects and, second, that the distribution of flavonoids varies among plant species. However, it is necessary to establish whether the distribution specific flavonoids overlaps with the presence or absence of these flavonoids in host and/or non-host plants. Aldehydes are straight-chain chemical compounds that are saturated (single bond) or unsaturated (double bond) with the carbonyl functional group responsible for the insecticidal activity, such as propanal, 2-methyl-2-butenal and 2-methyl-2-butenal. The biological activity of aldehydes activity lies in acting as a bioinsecticide and with phytotoxicity against insects that insects that attack fruits, vegetables and grains. This functional group can be used as a post-harvest insecticidal control agent, eliminating 100% of the aphid pests that attack grains, with undetectable damage to the functional characteristics of the products tested [20].

Monoterpenes are secondary metabolites biosynthesized in plant essential oils [21]. They consist of an isoprene base structure and, when they contain oxygen, they are structuralize into terpenoids. The insecticidal and acaricidal activity of polyhalogenated monoterpenes obtained from *Plocamium cartilagineum* was demonstrated against insects such as *Spodoptera frugiperda*, a larva that damages corn, sugarcane or on corn, sugar cane or onion; *Heliothis virescens*, larva that damages tobacco, cotton or tomato; and tobacco, cotton or tomato and *Aphis fabae*, an aphid or bean aphid that can also affect beets, among others. Argandoña et al. (2000) isolated two halogenated monoterpenes; mertensene and violacene, obtaining also two derivatives of the first one; dibromomertensene and dihydromertensene, to test their insecticidal activity against insecticidal activity against the tomato larvae *Tuta absoluta* and the cereal aphid *Schizaphis graminum*. When the compounds were tested against tomato larvae, 100% mortality was observed when mertensene was applied and 80% for mertensene and, 80% for violacene and dibromertensene (obtained by the addition of 2 bromides in the double bond of mertensene). In the case of for aphids, violacene showed 92% mortality and the other compounds did not show the other compounds did not show effectiveness at any of the concentrations used. concentrations used [22-27].

3.2 PRINCIPAL COMPONENTS ANALYSIS OF NUTRIENT CONTENT

The Inductively Coupled Plasma (ICP) is an ionization source that together with an Optical Emission Spectrophotometer (OES) constitutes the ICP-OES equipment. In this equipment, ICP (inductively coupled plasma) is used to generate excited atoms that emit electromagnetic radiation upon return to their ground state. The wavelength of this radiation is characteristic of

each element (macroelements and microelements), being a very selective technique. The amount of radiation emitted is proportional to the concentration of the analyte. This fact allows, after comparison with standards, to quantify the analyte content with accuracy and precision [28-29]. Induction plasma is an ionized gas (plasma source) containing free electrons and cations that operates under conditions of high temperatures and low pressures, usually operated by a free radiofrequency generator. [30-31].

The elements three asterisks in each column mean that they are the nutritional elements in which each plant stands out for having a greater presence in comparison with the others; those into two asterisks are the nutritional elements that it shares with those next to it and in one asterisk the nutritional elements with the lowest concentration in that plant (Table 3).

Table 3

Macroelement and microelement concentrations (mg/kg)

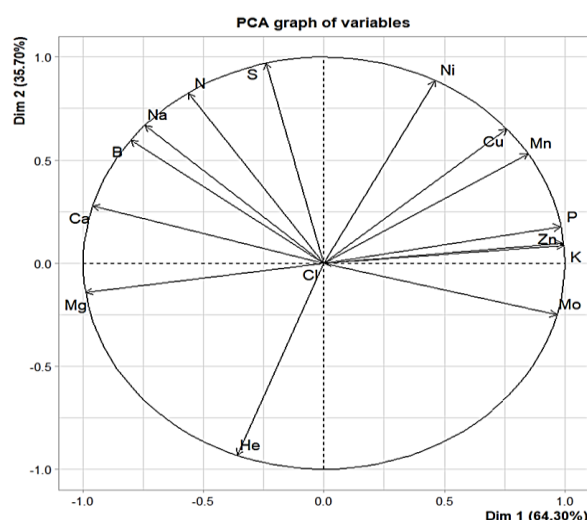
Elements	Pink grass (R. repens)	Huizache (V. farnesiana)	Higuerilla (R. communis)
N	25,600.00*	35,200.00***	41,400.00***
P	3,700.00**	1,700.00****	3,100.00**
K	17,400.00*	10,100.00***	14,600.00**
Ca	6,400.00*	28,500.00***	22,000.00***
Mg	2,300.00**	2,600.00**	2,400.00**
S	2,200.00*	3,000.00****	4,900.00****
Na	90.00*	467,000.00*	563,000.00*
Cl	0.00**	0.00**	0.00**
Fe	81.50****	94.50***	54.00*
Zn	31.40***	8.58****	22.90**
Mn	56.90****	33.40*	59.30***
Cu	9.95****	4.46*	11.70***
B	3.96*	22.50****	24.00****
Ni	1.26*	0.60*	2.17***
Mo	3.80***	0.25*	1.38****

The three plant extracts samples are found in different quadrants (Figure 5). The higuerilla is found in quadrant one, standing out for the dominance of elements such as manganese, copper and nickel. In contrast, iron seems to be the most deficient element for higuerilla. This same plant has similar amounts of phosphorus, potassium and zinc against rosado grass, due to its location in quadrant IV adjacent to it. The pink grass only stands out in one element which is molybdenum, it can be seen that it is the plant with the highest amount of this element, also

for zinc. The opposite quadrant to IV is II, therefore, it can be said that pink grass is the most deficient of the three biological samples in the following elements: nitrogen, calcium and sulfur for macroelements. As for the microelements they are: sodium, boron and nickel (Figure 6). Next, analyzing quadrant III we can find huizache, which stands out for containing a high concentration of elements such as iron, magnesium (2,600 mg/kg), but in this last one it does not seem that the difference is so high in comparison with the other two plants higuerrilla (2,400 mg/kg) and pink grass (2,300 mg/kg). Finally, the element chlorine appears in the middle, since in none of the samples its presence was reported, giving a result of 0 mg/Kg.

Figura 5

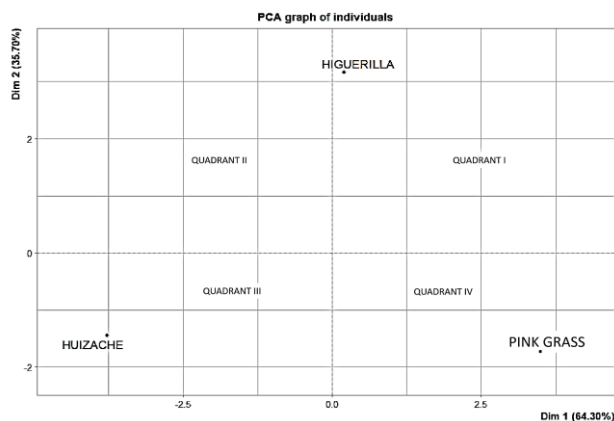
Principal Components Analysis graph of macroelements and microelements variables



Source: Authors (2025).

Figure 6

Principal Components Analysis graph of individuals plants, higuerrilla (R. communis), b) huizache (V. farnesiana) and c) pink grass (R. repens)



Source: Authors (2025).

The higuerilla plant is rich in microelements such as manganese, copper and nickel compared to the other two, and in macroelements such as nitrogen. The pink grass has high amounts of microelements such as zinc and molybdenum, and does not stand out with high concentrations of any macroelements, but rather seems to have the lowest concentration of nitrogen, calcium and sulfur. Likewise, it is deficient in microelements such as sodium, boron and nickel. The huizache plant only stands out for being the one with the highest concentrations of calcium and iron. For most of the microelements such as manganese, copper, nickel and molybdenum, it is the plant with the lowest amounts, and for the three plants there is no chlorine and similar amounts of magnesium ranging from 2,300 mg/kg to 2,600 mg/kg. As for the elements phosphorus and potassium, pink grass and higuerilla have similar values, for the first element from 3,100 to 3,700 mg/kg. On the other hand, for the second element, potassium, the values range from 14,600 to 17,400 mg/kg. The higuerilla and the pink grass can complement each other well to make a mixture high in microelements such as: manganese, copper, boron, nickel and molybdenum.

Rani et al (2023) analyzed the methanolic leaf extract of *Thalictrum foliolosum* by ICP-MS technique to trace mineral elements and the result revealed the presence of important micronutrients such as manganese (Mn), iron (Fe), zinc (Zn), chromium (Cr), copper (Cu) and potassium (K). These minerals are cofactors for more than 3,000 regulatory enzymes of various metabolic pathways [32]. Wieczorek, et al (2022) mention that ICP-OES is an advanced instrumental method that allows less expensive and less time-consuming trace element analysis with adequate higher precision and repeatability evaluation [33]. Trimmel et al, (2023) analyzed seven certified reference materials for plants: apple tree leaves, peach tree leaves, hay powder, aquatic plant, twigs and leaves of bush, spinach leaves and green tea to determine their mass fractions of 48 elements by ICP-MS/MS, which were lithium (Li), beryllium (Be), sodium (Na), magnesium (Mg), aluminum (Al), calcium (Ca), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), germanium (Ge), arsenic (As), Se, rubidium (Rb), strontium (Sr), iodine (I), Nb, molybdenum (Mo), silver (Ag), cadmium (Cd), Sb, tellurium (Te), barium (Ba), La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Ta, Tl, lead (Pb), Bi, Th and U [34]. On the other hand, Sadee et al. (2023) evaluated the concentration of various metals in vegetables of common local consumption by ICP-MS, these analyzed plants were tarragon, laurel, dill, Syrian mesquite, vine leaves, thyme, arugula, basil, common purslane and parsley. The concentration ranges analyzed were: 76-778 for aluminum (Al), 10-333 for boron (B), 4-119 for barium (Ba), 2812-24645 for calcium (Ca), 0.1-0.32 for cobalt (Co), 201-464 for iron (Fe), 3661-46400 for potassium (K), 0.31-1.53 for lithium (Li), 860-

14330 for magnesium (Mg), 16.20-71.5 for manganese (Mn), 612-4725 for sodium (Na) and 15.8-46 $\mu\text{g g}^{-1}$ for zinc (Zn) [35]. Sultana et al. (2022) compared the results obtained in the determination of the content of essential elements such as manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn) in plant samples using different analytical approaches, as well as the most commonly used spectroscopic methods in the field of plant analysis, such as acid digestion in combination with atomic emission (AES) and atomic absorption spectrometry (AAS), being the analysis by inductively coupled plasma optical emission spectrometry (ICP-OES) a sustainable and rapid analytical alternative [36]. Sukru et al. (2022) determined trace metal concentrations of magnesium (Mg), iron (Fe), copper (Cu), lead (Pb), chromium (Cr), arsenic (As), nickel (Ni), zinc (Zn), and Selenium (Se) in dried red plum samples from Turkey. These were determined by ICP-OES technique after solubilization in microwave digestion methods. The concentrations of the elements in dried red plum samples were 44-47 of magnesium (Mg), 15-18 of iron (Fe), 03.1-3.2 of copper (Cu), 4.1-4.4 of lead (Pb), 1.4-1.6 chromium (Cr), 1.1-1.3 arsenic (As), 2.5-2.8 nickel (Ni), 3.4-3.7 zinc (Zn) and 4.2-4.5 selenium (Se) at $\mu\text{g/g}$ concentrations [37].

4 CONCLUSIONS

The specialized secondary metabolites detected in higuerilla (*R. communis*) were: chalcones, auronos, flavonols, sterols, condensed tannins, saponins and triterpenes. The specialized secondary metabolites detected in huizache (*V. farnesiana*) were: flavones, flavonols, sterols, condensed tannins, saponins and triterpenes. The specialized secondary metabolites detected in pink grass (*R. repens*) were: flavones, flavonols, methylsterols, phenols and triterpenes. With respect to the metallome of the extracts analyzed by the ICP-OES technique, whose method determined quickly and with high precision the trace elements, it was quantified that the higuerilla plant is rich in microelements such as manganese, copper and nickel compared to the other two, and in macroelements such as nitrogen. The pink grass has high amounts of microelements such as zinc and molybdenum, and does not stand out with high concentrations of any macroelements, but rather seems to have the lowest concentration of nitrogen, calcium and sulfur. The huizache plant only stands out for being the one with the highest concentrations of calcium and iron.

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NUCLEAR ENERGY: PROBLEM OR SOLUTION FOR THE BRAZILIAN ELECTRICITY SECTOR?

ENERGIA NUCLEAR: PROBLEMA OU SOLUÇÃO PARA O SETOR ELÉTRICO BRASILEIRO?

ENERGÍA NUCLEAR: ¿PROBLEMA O SOLUCIÓN PARA EL SECTOR ELÉCTRICO BRASILEÑO?



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ABSTRACT

The present article explores nuclear energy in the context of the Brazilian electrical system, beginning with a global overview that highlights the importance of this energy source in the global energy matrix, emphasizing its crucial role in diversifying energy sources and mitigating carbon emissions. The study also examines this global perspective and the specific situation in Brazil, where the contribution of nuclear energy remains modest. Furthermore, the inherent qualities of this source are noted, such as its energy density and its capacity to provide a continuous and reliable energy supply. Additionally, the associated benefits are analyzed, including the reduction of dependence on fossil fuels and the decrease in greenhouse gas emissions. However, the risks involved are also addressed, such as the management of radioactive waste and the potential for nuclear accidents. Thus, there is a balance observed between the qualities and potential risks of this alternative, enabling the implementation of strategies to ensure energy security within the Brazilian electrical system.

Keywords: Nuclear Energy. Electrical System. Energy Diversification. Carbon Emissions.

RESUMO

O presente artigo explora a energia nuclear no contexto do sistema elétrico brasileiro, iniciando com um panorama global que ressalta a importância dessa fonte energética na matriz elétrica mundial, sublinhando seu papel crucial na diversificação das fontes de energia e na mitigação das emissões de carbono. O estudo também examina essa visão global e a situação específica do Brasil, onde a contribuição da energia nuclear ainda é modesta. Ademais, constata-se as qualidades inerentes a essa fonte, como sua densidade energética e a capacidade de fornecer uma energia contínua e confiável. Além disso, são analisados os benefícios associados, incluindo a redução da dependência de combustíveis fósseis e a diminuição das emissões de gases de efeito estufa. Contudo, também são abordados os riscos envolvidos, como a gestão de resíduos radioativos e o potencial para acidentes nucleares. Assim, observa-se uma ponderação acerca das qualidades e eventuais

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riscos dessa alternativa, possibilitando a implementação de estratégias para assegurar a segurança energética no sistema elétrico brasileiro.

Palavras-chave: Energia Nuclear. Sistema Elétrico. Diversificação Energética. Emissões de Carbono.

RESUMEN

El presente artículo explora la energía nuclear en el contexto del sistema eléctrico brasileño, iniciando con un panorama global que destaca la importancia de esta fuente energética en la matriz eléctrica mundial, subrayando su papel crucial en la diversificación de las fuentes de energía y en la mitigación de las emisiones de carbono. El estudio también examina esta visión global y la situación específica de Brasil, donde la contribución de la energía nuclear aún es modesta. Además, se constatan las cualidades inherentes a esta fuente, como su densidad energética y la capacidad de proporcionar una energía continua y confiable. Asimismo, se analizan los beneficios asociados, incluyendo la reducción de la dependencia de combustibles fósiles y la disminución de las emisiones de gases de efecto invernadero. No obstante, también se abordan los riesgos involucrados, como la gestión de residuos radiactivos y el potencial de accidentes nucleares. De este modo, se observa una ponderación acerca de las cualidades y los eventuales riesgos de esta alternativa, possibilitando la implementación de estrategias para garantizar la seguridad energética en el sistema eléctrico brasileño.

Palabras clave: Energía Nuclear. Sistema Elétrico. Diversificación Energética. Emisiones de Carbono.

1 INTRODUCTION

The history of nuclear energy, according to Passos *et al.* (2011) is intrinsically linked to the development of humanity, as the philosophers of Ancient Greece were pioneers in formulating the idea that matter is made up of atoms. Not only relevant names such as Marie and Pierre Curie and leading advances that made the understanding and application of this energy source possible. However, it was not until the 1930s that scientists observed the potential of nuclear fission, paving the way for numerous transformations and advances. Nevertheless, the Manhattan Project corroborated significantly, since it aimed to obtain the nuclear bomb and, due to this, intensive investments were made to achieve this objective. This organization had great names in science, such as Enrico Fermi and Niels Bohr, and was led by Robert Oppenheimer, popularly known as the "father of the atomic bomb".

Nuclear energy, according to Eletronuclear (2024), consists of a form of energy derived from the atomic nucleus, being characterized by the release of a significant amount of energy during nuclear processes and presents nuclear fission and nuclear fusion as its main phenomena. Nuclear fission is based on splitting the nucleus of an atom into smaller fragments releasing energy. Nuclear fusion, on the other hand, is based on the combination of two nuclei and, consequently, on the release of energy.

For the generation of nuclear energy, according to the Nuclear Energy portal (2024), specific raw materials are used, especially the radioactive isotope uranium-235. Uranium-235 is crucial in nuclear fission processes in nuclear reactors, as it has a high susceptibility to fission and therefore results in the release of energy. Also, to ensure an efficient procedure, it is necessary to enrich uranium to increase the concentration index of the isotope uranium-235, since, under natural conditions, only a small portion of this element is composed of this isotope.

Today, that is, nowadays, the use of this energy source as an alternative worldwide, since global warming puts pressure on the use of fossil fuels and, for these reasons, the nuclear source is an interesting option, as Gomes (2017) elucidates. Undoubtedly, this source plays a strategic role in the global panorama, providing an energy component that can meet world demand in an efficient and sustainable way. Together, the diversification of energy sources is crucial to reduce dependence on fossil fuels and contribute to energy security. Likewise, it provides an increase in energy security by reducing the country's vulnerability to fluctuations in fuel prices and supply interruptions. Therefore, safe production is essential for energy autonomy, positively impacting the economy and, for this, it is imperative to achieve strict standards of waste management and safety.

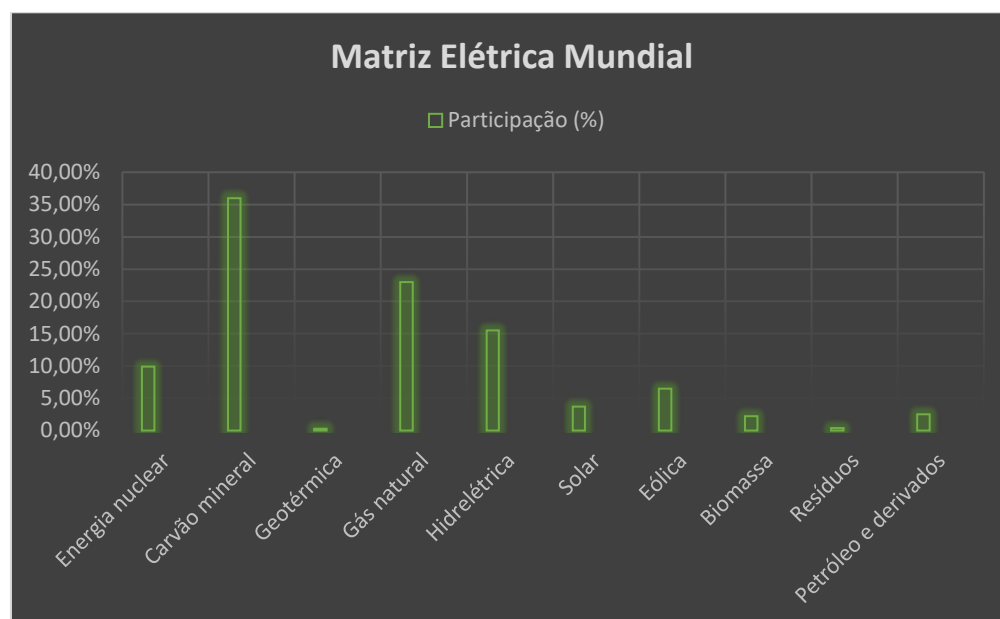
2 GLOBAL OVERVIEW

This aspect plays a fundamental role in the global energy landscape, being an indispensable source for many countries. Currently, the world has a diversified electricity matrix and, according to EPE (2023), it is mostly composed of mineral coal and natural gas. Therefore, Figure 1 shows the substantial participation of fossil fuels and the complementarity of renewable sources such as solar, wind, hydroelectric and the significant contribution of nuclear sources.

Furthermore, as mentioned earlier, nuclear energy is indispensable for some countries, making them significantly dependent on this source. In this way, it is feasible to observe the energy situation in France, where this source represents 70% of the generation capacity, as presented by Bhutada (2022). In addition, this energy source accounted for 2,553 TWh of global energy production, led by the United States of America (30.9%), China (13.5%) and France (13.3%).

Figure 1

World Electricity Matrix



Source: The authors.

Not only that, it is a feasible alternative for the reduction of fossil fuels that are aggressive to the environment and, in addition, certain countries have a greater allocation to nuclear energy due to issues such as high energy efficiency and geoFigureical aspects. Thus, the relevance of this supply alternative is reiterated, since nations such as France, Slovakia and Ukraine have, respectively, 70.6%, 53.1%, and 51.2% of their energy matrix in this source. However, still cited by Bhutada (2022), there are 448 nuclear reactors in operation in the world, 96 in the USA, 58

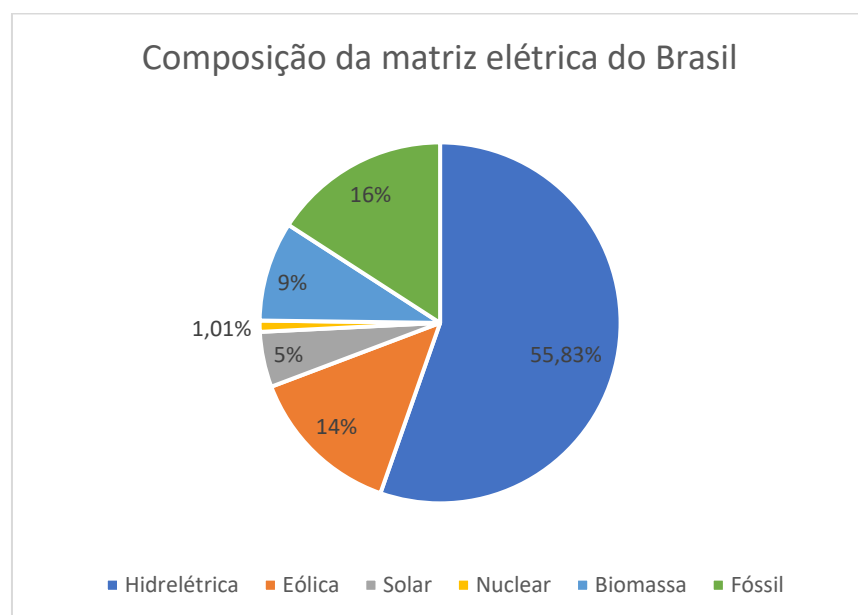
in France, and 50 in China. Moreover, the prospect is for expansion, since China plans to invest 440 billion dollars to build 150 new reactors by 2035.

3 NUCLEAR ENERGY IN BRAZIL

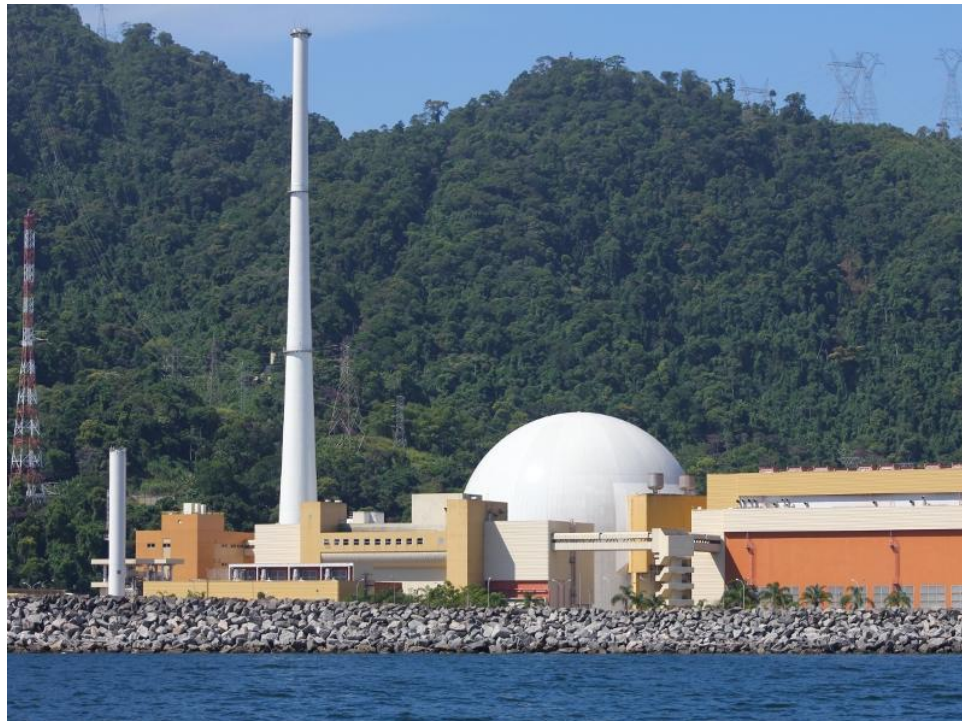
Historically, the Brazilian electricity matrix is diversified and considerably clean, with a tendency to become increasingly renewable, causing wind and solar energy to gain greater share. In addition, Montalvão (2012), the renewable profile guarantees low tariffs and energy security, considering that these sources are inexhaustible. As a result, Brazil has the largest electricity system in Latin America and, consequently, is among the ten largest electricity producers on the planet.

Currently, the matrix consists of various energy sources, such as hydroelectric, wind, thermal, nuclear, photovoltaic and biomass, as illustrated in Figure 2. In addition to this factor, according to Guimarães (2016), it is observed that nuclear energy is a fundamental part of the resolution of the national hydrothermal energy transition. Moreover, it is possible to analyze the fundamental link between energy availability and consumption with the degree of economic development of the country, since such factors are directly proportional. Therefore, in view of the growing energy demand, it is necessary to increase national generation to meet this problem and, due to this, nuclear energy is viable in view of its generational predictability.

In addition, Brazil is one of the countries that has a wide domain over the uranium enrichment cycle and, at the same time, has reserves in its territory. Allied to this, as previously mentioned, the diversification of the electricity matrix ensures a low tariff and, if such a scenario did not occur, Brazil would present a significant increase in tariffs and local industries would lose competitiveness in the international market. Nevertheless, as stated in the National Energy Balance 2024 (2024), nuclear energy represents 1.2% of the entire Domestic Energy Supply (OIE), being generated through the Angra 1 (illustrated in Figure 3) and Angra 2 plants, in addition to the Angra 3 construction project being in progress.

Figure 2*Composition of the Brazilian electricity matrix*

Source: The authors.

Figure 3*Angra dos Reis nuclear power plant (RJ)*

Source: NS Energy

3.1 REGULATORY BODIES

In addition, in the Brazilian electricity sector, there are several regulatory bodies and entities that manage the competent aspects of nuclear energy, however, the following stand out:

- National Nuclear Energy Commission (CNEN): It is responsible for the aspects of nuclear safety, radiological protection and regulation of nuclear activities in the country. Thus, it licenses and inspects nuclear installations, in order to ensure that the operation complies with safety standards;
- National Electric Energy Agency (ANEEL): Its objective is to regulate and supervise the production, transmission, distribution and commercialization of electricity in Brazil;
- National Electric System Operator (ONS): Seeks to coordinate and control the operation of electricity generation and transmission in the SIN (National Interconnected System);
- Ministry of Mines and Energy (MME): Coordinates the country's energy policy and defines the guidelines for the development of the nuclear sector, in line with safety and sustainable development policies.

4 ENERGY EFFICIENCY

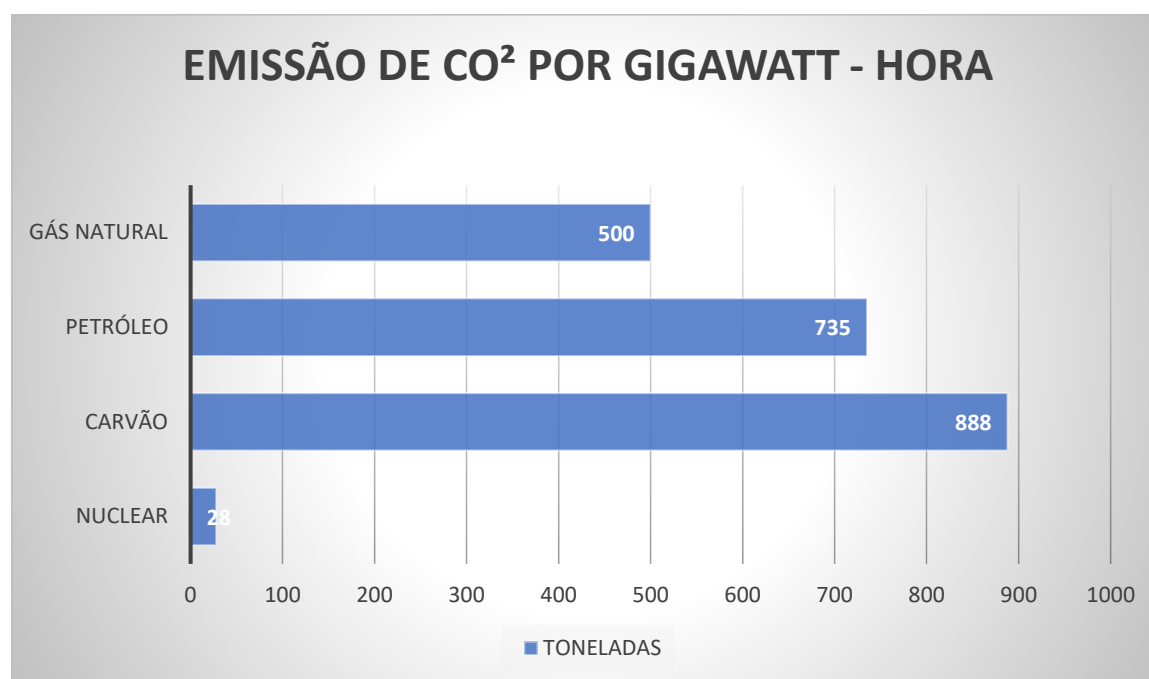
The demand for uranium comes from nuclear power plants, consequently, it is the companies that use this element as fuel for their reactors and, on the other hand, the *players* that supply this raw material are the mining companies. In addition, it is noted that the superiority of uranium as an energy source occurs as a result of the level of energy density, one of the main competitive advantages of this alternative. Likewise, Conte (2021) illustrates energy efficiency through a proportionality, where a uranium pellet (about 1 centimeter high and in diameter, with the height being greater than the diameter), is equivalent to 120 gallons of oil, 17,000 cubic feet of natural gas or 1 ton of coal, thus evidencing the high density of the material and, as a result, your generational capacity. However, it is noted that the competitive advantages of this source stimulate its use in the context of energy transition.

In addition, the energy density of uranium is one of the main causes of the increase in demand, since it allows the storage of substantial amounts of the material in a logistics warehouse. In this way, according to Bhutada (2021), it becomes the only energy source capable of being stored under these conditions, corroborating energy security and enabling exponential production from a tiny amount of raw material. Therefore, as Bhutada (2021) explains, due to the high density levels of uranium, it requires, on average, 75 times less space than the photovoltaic alternative and 360 times less land than the wind option. In addition, the relative availability of the material is a fundamental factor in its viability, as it is 37 times more abundant than silver and 700 times more present than gold (Bhutada, 2021).

However, the sustainable aspects of the energy of atomic nuclei are another competitive advantage that this alternative has, especially with regard to CO² emission per Gigawatt hour. Thus, it is observed in Figure 4 the favorable scenario in relation to nuclear energy in view of this issue. (BBC News, 2022).

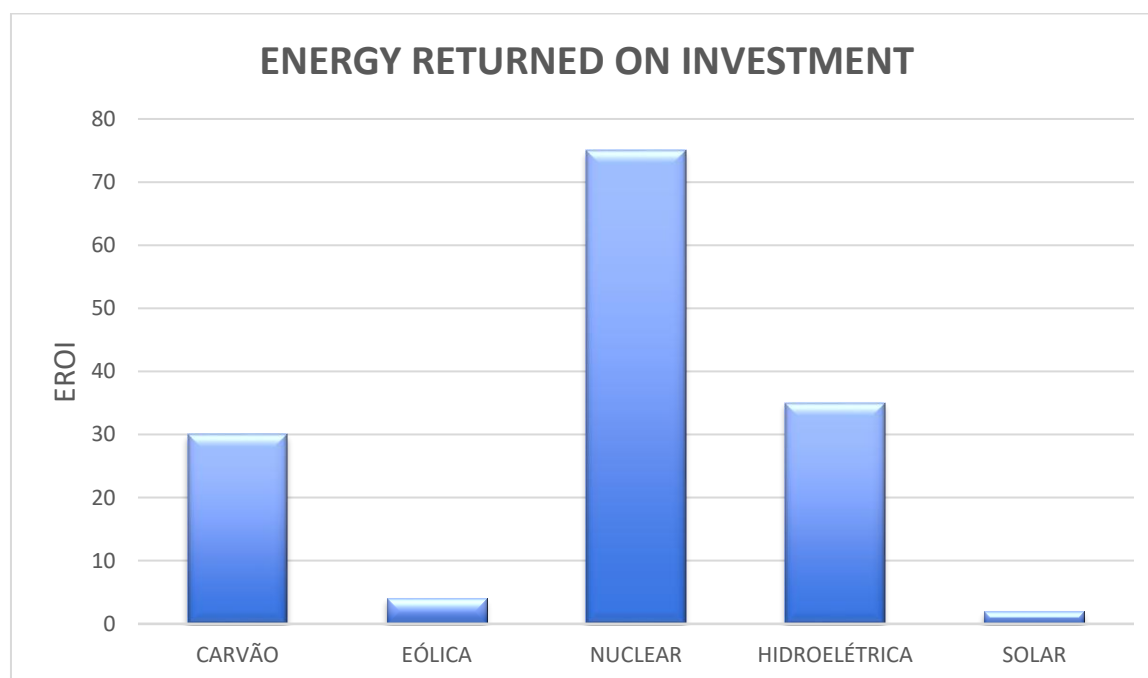
Figure 3

CO² emission per Gigawatt - Hour



Source: Prepared by the authors.

Additionally, according to the *Corporate Finance Institute* (2024), *Energy Return On Investment*, abbreviated as *EROI*, is a financial indicator that illustrates energy efficiency, as it consists of the ratio between the amount of energy generated by a source and the amount used to obtain this resource. Therefore, it is noted that any number equal to 1 represents the equilibrium point, while values greater than 1 consist of a positive balance. However, as shown by the *Corporate Finance Institute* (2024) and illustrated in Figure 5, the EROI that nuclear energy presents is substantially higher than its peers, and is therefore a competitive advantage.

Figure 5*Energy Returned On Investment*

Source: Prepared by the authors.

5 BENEFITS

This type of energy, as well as others, has positive and negative points, however, it is necessary to weigh these aspects rationally to verify its feasibility of implementation. However, nuclear energy has some substantial competitive, economic and strategic advantages and, due to this, it becomes attractive for implementation in certain conjunctures and needs.

A priori, nuclear energy is of great importance to ensure the security of energy supply due to high predictability, generational constancy, storage capacity and independence from climatic factors. Not only that, the expressive density of the material used allows the production of high amounts of electricity through a small amount of raw material and, therefore, as previously discussed, the substantial energy efficiency of this source is noted. Furthermore, according to Montalvão (2012), the use of this source does not emit greenhouse gases, promotes a low release of waste and does not require a significant area for the construction of the plant in relation to other alternatives. In other words, it is possible to analyze the rigidity of the procedures related to the safety of the facilities and the intense process of continuous improvement of them, causing the plants to demonstrate considerable increases in the levels of protection.

In addition, it promotes the diversification of the energy matrix, corroborating the transition movement of this sector. Thus, it is observed that the use of various generational sources is a strategic objective of extreme relevance for numerous countries, since it ensures geopolitical

advantages, increases energy security, reduces vulnerability to fluctuations in international prices and possible interruptions in supply. Therefore, with assertive investment and development policies, nuclear energy can expand its relevance and solidify the national electricity system (Plum, 2024).

Likewise, it contributes significantly to technological development and scientific innovation, as the sector is marked by constant advances in areas such as nuclear physics, engineering, and safety measures and procedures. Therefore, such evolutions are not restricted only to the energy industry, but also have applicability in other fields, such as agriculture through food irradiation techniques, and in medicine, through radiotherapy and other diagnostic imaging. In addition to this factor, Tang (2008) emphasizes that the use of capital destined to investments in energy strengthens the energy infrastructure, promotes scientific and technological progress, positively impacting society.

6 RISKS

The nuclear source has substantial positive aspects; However, it also has negative conjunctures. Among the most well-known risks, those of an economic, physical and strategic nature are observed. At the same time, according to Goldemberg (2008), other energy modalities also employ risks, but not on the same scale as nuclear energy. Consequently, with the nuclear source, the associated problems acquire greater expressiveness.

Economic risks refer to the resources allocated to security and their necessary procedures, which, consequently, reflect on the increase in cost, making it difficult to structure projects to finance these investments. However, bureaucracy and public opposition can cause delays in reactor construction, leading to increased capital expenditure (a type of resources set aside for the purchase of goods to increase production, also known as *CAPEX*) and incurring interest.

In addition, strategic risks, as highlighted by Goldemberg (2008), refer to the geopolitical implications arising from the possession of a nuclear device and, potentially, the allocation of resources for war purposes. As a result, treaties and agreements for nuclear non-proliferation were established, since this issue was the trigger for certain conflicts. In addition, the risk inherent in the acceptance of public opinion is an important factor that must be weighed in decision-making, since there are strong anti-nuclear movements in Brazil and in the world. In addition, the existence of geopolitical risk through military incursions is verified, see the existing situation in Niger and its possible impact on the country's nuclear activity.

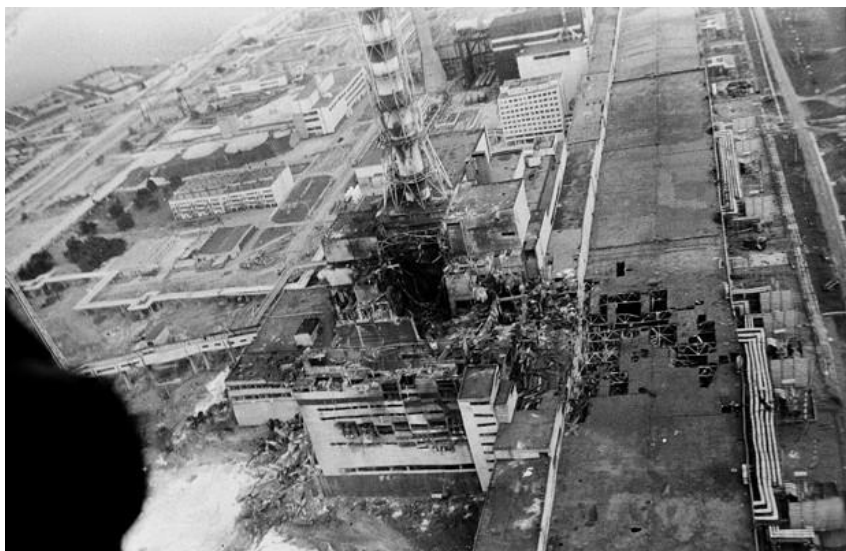
In fact, the physical risks consist of possible structural insecurity related to nuclear leaks and explosions. By the way, the concern with the disposal of the material used is latent, since there is no appropriate environment to deposit this material to this day. Likewise, the emblematic episodes of nuclear accidents elucidate the potential danger that these plants, if not managed and built in the right way, can bring. In other words, human history has faced 3 major nuclear tragedies, Chernobyl, Fukushima and Three Mile Island.

Nevertheless, the public acceptance of nuclear power plants, mainly due to the lack of knowledge on the subject, is a factor that should be considered in the analysis of implementation, even if it does not represent impediments in many countries. However, according to Guimarães (2016), the biggest obstacle is the high CAPEX and the difficulties of designing projects to make these long-term investments viable.

First, the Chernobyl incident, explained in Figure 6, happened on April 26, 1986, when the technical team in charge of analyzing the operation of the reactor did not comply with the safety regulations and, in view of the plant's obsolete technology, the reactor showed significant instability and, consequently, affected the explosion of reactor 4. In addition, according to Montalvão (2012), Chernobyl occurred due to a combination of three aspects: government irresponsibility, human error, and outdated technology.

Figure 6

Chernobyl power plant, damaged after the explosion, in a photo from May 1986



Source: G1

In addition, the occurrence of Three Mile Island dated 1979 and shown in Figure 7 was caused by an operational mistake and failure in an equipment. At the same time, the lack of

preventive maintenance and poor qualification of professionals demonstrate the negligence of those responsible in a situation that released a substantial amount of radioactive liquid (water) into a river in the state of Pennsylvania.

Figure 7

Aerial view of the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania, the scene of a nuclear accident



Source: WTOP News

Subsequently, the accident in Fukushima, observed in Figure 8, in which radioactive water leaked into the sea and emitted radioactive gas into the atmosphere, was caused by poor design and planning of the plant's infrastructure. Due to the tsunami that devastated Japan, structural deficiencies came to light and caused severe damage.

Figure 4

Aerial view of the Fukushima nuclear power plant after the explosion



Source: Daily Mail

In addition to the factors explained above, radioactive waste is substantially dangerous to society, since it consists of all waste material that is made up of radioactive chemical compounds. Such waste is obtained from hospitals and nuclear power plants and, in addition, endangers not only human beings, but also nature. As a result, the proper disposal of this content is essential to prevent impacts. Therefore, material with low or medium levels of radioactivity is deposited in underground facilities, commonly in power plants. In addition, high-risk substances are treated through management and confinement for significant periods due to their durability. In addition, in view of the risk aspects discussed above, Eletronuclear (2024) emphasizes the importance of the correct adoption of safety procedures and the constant evolution of nuclear technology, minimizing possibly harmful particularities and corroborating the diffusion of the use of this energy source.

7 CONCLUSIONS

For all that has been exposed throughout this work, the presence and relevance of nuclear energy both in the world electricity matrix and in the Brazilian scenario is evident, thus verifying the strategic role it plays in the diversification of energy sources and in the mitigation of carbon emissions. Not only that, the nuclear source proves to be viable and beneficial, since it presents expressive energy density indexes and corroborates with the increase in predictability in energy generation, acting as an interesting alternative to complement the use of other options.

Above all, in addition to the high efficiency rates, this energy source also has the benefits of high storage capacity, expressive durability and exponentially rigorous safety processes that

contribute to its credibility. In addition, it is imperative to highlight the risks existing in the operation, especially those of a physical, economic and strategic nature that strongly oppose the positive aspects, making it necessary to have a rational consideration to make a decision. Moreover, economic risks are linked to the intensive need for investments to finance these projects, while strategic risks represent the geopolitical issues inherent to the activity. Therefore, physical risks consist of the possibility of an operational failure or accident occurring. Thus, it is noted that even with the existing risks, the qualities of nuclear energy stand out as the demand for energy security and independence grows.

In addition, the high level of acceptance of the population living in areas close to the reactors is reiterated, in addition to positive socioeconomic impacts through the qualified labor and jobs offered. In addition, the strict safety and *compliance* procedures corroborate to expand the use of this energy. Thus, due to the current situation of energy transition and urgency in reducing carbon emissions, nuclear energy behaves as a fundamental alternative for solving the energy supply deficit, as it has substantially higher efficiency rates than other alternatives, in addition to requiring smaller amounts of the land production factor and having the highest EROI. In view of the above, it is found that the nuclear alternative is viable to solve the Brazilian energy problems, since even though it still has a limited participation in the national electricity matrix, the potential and need for growth is remarkable. With this, it is interesting to spend more investments to promote the evolution of the sector and contribute to the assertive realization of the energy transition, obtaining a safe and more capable electricity matrix to supply the existing deficit.

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CONTEMPORARY LEGAL APPROACHES FOR TECHNOLOGICAL DEVELOPMENT

ABORDAGENS JURÍDICAS CONTEMPORÂNEAS PARA O DESENVOLVIMENTO TECNOLÓGICO

ENFOQUES JURÍDICOS CONTEMPORÂNEO PARA EL DESARROLLO TECNOLÓGICO



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ABSTRACT

Technological development simultaneously drives economic advancement and generates challenges that often exceed the regulatory capacity of existing legal systems. Grounded in critical theoretical perspectives, the paper rejects the notion of neutral technological progress and emphasizes the role of power structures and institutional choices in shaping technological trajectories and their social consequences. Drawing on an interdisciplinary theoretical framework that integrates the political economy of technological progress, legal theory, and methodological approaches to legal research, this study aims to understand key events of the Digital Revolution, the role of integrating different methodological approaches, and to contribute to a more flexible, responsive, and technologically compatible legal approach aligned with the dynamics of contemporary technological development.

Keywords: Scientific Research. Emerging Technologies. Law.

RESUMO

O desenvolvimento tecnológico impulsiona simultaneamente o avanço econômico e gera desafios que frequentemente excedem a capacidade regulatória dos sistemas jurídicos existentes. Fundamentado em perspectivas teóricas críticas, o artigo rejeita a noção de progresso tecnológico neutro e enfatiza o papel das estruturas de poder e das escolhas institucionais na configuração das trajetórias tecnológicas e de suas consequências sociais. Com base em um arcabouço teórico interdisciplinar que integra a economia política do progresso tecnológico, a teoria jurídica e abordagens metodológicas da pesquisa jurídica, este estudo busca compreender eventos-chave da Revolução Digital, o papel da integração de diferentes abordagens metodológicas e contribuir para uma abordagem jurídica mais

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flexível, responsiva e tecnologicamente compatível, alinhada às dinâmicas do desenvolvimento tecnológico contemporâneo.

Palavras-chave: Pesquisa Científica. Tecnologias Emergentes. Direito.

RESUMEN

El desarrollo tecnológico impulsa simultáneamente el avance económico y genera desafíos que a menudo superan la capacidad regulatoria de los sistemas jurídicos existentes. Basado en perspectivas teóricas críticas, el artículo rechaza la noción de progreso tecnológico neutral y enfatiza el papel de las estructuras de poder y las decisiones institucionales en la configuración de las trayectorias tecnológicas y sus consecuencias sociales. A partir de un marco teórico interdisciplinario que integra la economía política del progreso tecnológico, la teoría jurídica y enfoques metodológicos de la investigación jurídica, este estudio busca comprender los eventos clave de la Revolución Digital, el papel de la integración de diferentes enfoques metodológicos y contribuir a un enfoque jurídico más flexible, receptivo y tecnológicamente compatible, alineado con las dinámicas del desarrollo tecnológico contemporáneo.

Palabras clave: Investigación científica. Tecnologías emergentes. Derecho.

1 INTRODUCTION

Technological development has both the power to propel humanity toward its economic peak and the capacity to generate problems that the law is incapable of managing. In the constantly evolving landscape of technological advancement, the transformative potential of emerging technologies (...) is reshaping the foundations of industries and societies (Holland, 2020).

In this sense, an analysis of the perception of the impact of the technological revolution on society, and of how the definitions of Law change as one overlaps the other, becomes essential, since “technological changes are a constant throughout history as are influential people deciding their directions” (Acemoglu and Johnson, 2024, p. 184).

The study of law and information technology comes with an inherent contradiction in that while technology embraces notions such as internationalization and globalization, the law, for the most part, is to a certain extent still confined to national borders (Greenstein, 2022).

Thus, it is necessary to understand the role of different methodological approaches in research concerning Law in the face of advanced technological development and its implications, because at present “the current legal frameworks that regulate emerging technologies reflect a constantly changing landscape, seeking to deal with the rapid evolution of innovations,” attempting to adapt existing legislation to new problems, yet without offering the necessary adaptability and flexibility (Lescrauwaet et al., 2022).

Contemporary scientific literature recognizes that technological development constitutes a structural phenomenon of social, economic, and institutional transformation, whose effects go beyond the technical sphere and directly impact the field of Law. Studies focused on emerging technologies indicate that innovations such as artificial intelligence, blockchain, and biotechnology are reshaping the foundations of industries and societies, altering productive patterns, social relations, and forms of governance (Holland, 2020).

In this context, critical theoretical scholarship rejects the notion of automatic or neutral technological progress, emphasizing that technical transformations are historically conditioned and guided by human and institutional decisions. As argued by Acemoglu and Johnson (2024), technological changes have always coexisted with choices made by powerful actors responsible for defining their trajectories and distributing their benefits and risks. This approach highlights the centrality of power structures in shaping the social impacts of technology.

In the legal field, the literature points out that existing regulatory frameworks face difficulties in keeping pace with the speed and complexity of technological innovations. Recent

research indicates that prevailing regulatory models largely operate through incremental adaptations of preexisting legislation, resulting in partial and often insufficient responses to unprecedented problems (Lescrauwaet et al., 2022). This scenario reveals a mismatch between technological dynamics and the adaptive capacity of Law.

According to Karl Polanyi (2021), Law is a historical-cultural reality resulting from the integration of society, culture, and economics, making it impossible to understand it adequately through a one-dimensional approach. In this sense, the choice of descriptive, analytical, or critical approaches conditions the interpretation of technological phenomena and influences the formulation of legal solutions. Thus, the literature emphasizes the need to examine Law as situated knowledge, historically constructed, and sensitive to social and technical transformations.

Therefore, the theoretical framework of this study is grounded in the convergence of literature on technological revolution, the political economy of progress, and legal research methodology, providing the conceptual foundations necessary to support the hypothesis that current legal models lack sufficient flexibility and adaptability to address emerging technologies.

The data analysis was conducted based on a theoretical framework that articulates Law, technological revolution, and research, aiming to examine Law in light of technological innovations, with the objectives of historically and succinctly describing technological development, understanding the role of different methodological approaches in research concerning Law in the face of the digital revolution, and proposing practical solutions for a more flexible and adaptable approach to the topic.

2 THEORETICAL FRAMEWORK

Polanyi (2021) affirms that unemployed workers are a sign of economic malfunction. Hence, the spread of AI, pervading all sectors, from various types of work to personal life, raises a debate about its use and its social, economic, and legal implications.

Within this context, Acemoglu and Johnson (2024) affirm that AI seems set on a path that may aggravate the world's inequality. Thus, the discussion of whether its course can be changed or redirected towards a more beneficial trajectory, based on equality, empowerment of the people, and both flexible and adaptable norms.

Within this framework, Sunstein (2018) acknowledges the necessity of applying the Cost-Benefit Analysis in the setting of policy making, and understanding the context in which it may be applied. Regarding AI, it needs to be limited without restraining progress, in a way that does not benefit some to the detriment of others.

3 RESULTS AND DISCUSSION

Brief historical examination of key events of the Digital Revolution between 2000 and 2020 and its implications

Technological development, the economy, law, and society are intrinsically connected; although they are usually analyzed separately, in practice, it is hardly possible to separate them. “Technology is the way that collective human knowledge is used to improve nutrition, comfort, and health” (Acemoglu; Johnson, 2022, p.14), thought to be beneficial to society, although often creating a rift between those who have access and those who cannot.

The world Wide Web, developed by Tim Berners-Lee in 1989, was particularly transformative. It introduced the context of hypertext, which allowed users to navigate between different pages and resources through links, making the Internet more user-friendly and accessible to non-technical users. The Web’s introduction led to a dramatic increase in the Internet users, as it became easier for people to find and share information online (Hicks, 2024, p.22).

In this context, with the further development of the internet, from telephone wiring to wireless, alongside mobile communication, it rapidly evolved into the systems now used. Bergström et al (2024) affirmed that it “was built on the transition from circuit-switched to packet-switched data communication networks – a transition that spread across telecommunication domains and dissolved the borders between data and telecommunication”.

Furthermore, with the advent of Social Media, the relationship of people with each other and the Internet changed, as well as the definitions of privacy, image exposition, and fame, once content creation is as rewarded as the arts, economically and concerning public attention. Dhingra and Mudgal (2019) affirm that “as more and more people are becoming dependent on social media for different purposes, in the future also there is likelihood of emergence of even more sophisticated forms of social media which will cover the masses across the world”.

According to Mo and Ouyang (2025, p.512), “GenAI refers to a class of machine learning models typically trained using self-supervised learning and capable of producing outputs that closely resemble human-generated content”. Meaning that it generates a response based on a prompt, using the Internet as a database, and informally providing answers, resembling human behaviour, with no input of critical thought. It is fed on both the information online and shared by the user.

Within this framework, Artificial Intelligence (AI) development comes as a watershed moment, redefining all previous concepts. The use of AI extends to all aspects of contemporary life; Machine Learning was taken to another level; some specialists define it as machines or

algorithms capable of demonstrating “intelligent behaviour” or “advanced capabilities”, although there is not yet a consensus regarding that matter (Acemoglu; Johnson, 2024, p. 403).

Yet, according to Castán (2024), the issue concerning the lack of a concept of AI “may be explained both by the absence of a widely accepted technical definition of AI and by the lack of specific regulation in force, which has led to an absence of applicable legal definitions”. Despite the legal problem, this issue has not prevented its use in different fields, whether for various job applications, for entertainment, or for criminal practices, based on the ease with which the tools can be used.

Understanding the role of different methodological approaches in research concerning Law in the context of the Digital Revolution

The Academy has one of the most important roles as it has the capacity to explain phenomena and foresee possible scenarios concerning them, as well as influence society towards more beneficial paths.

There has been a complete paradigm shift in regard to the production, management and use of data, of knowledge and of information, which are key elements which have always defined and continue to define human relationships, economic structure and the fabric of modern society and science itself (Maiorana, 2025).

In this regard, it is necessary to discuss the methodological approach concerning the crescent development of digital technologies and its implications. The rise of a technology is not inherently beneficial to society as a whole; history proves that milestone moments devoid of human rights and law support often turn into a pretext for exploration, gap areas that previous law has to be adapted into, and economic advantage for an elite group, and not to all. Growth for a few can hardly be considered propitious (Acemoglu; Johnson, 2024).

Hence, the importance of understanding different methodologies regarding research lies in the desired outcome. It is crucial to integrate different fields of knowledge, such as economics, law, and sociology, with the analysis of the new technologies' impact, such as AI, to avoid the misuse of it for the lack of an adequate legal framework, since it “could disrupt the already fragile balance of the world order. This disruption could arise from state competition in AI technology and the application of AI in the military domain, which exists in a “gray zone” of international law and is not regulated” (Kykeyeva; Kurmangali; Aktai, 2024, p.5).

Academia plays a central role in the cultivation and exercise of this type of social power because universities build the perspectives, interests, and skills of millions of talented young people who will work in the technology sector. In addition, top academics often

work with leading tech firms and also directly influence public opinion. We would therefore benefit from a more independent academia (Acemoglu; Johnson, 2024, p.428)

Within this scope, it is paramount to consider the integration of various fields when it comes to the approach used in research concerning the impacts of digital technologies and their repercussions in Law, observing the necessity of norms without risking overregulation, aiming to secure the responsible use instead of restraining advancement. In this case, tools are not the issue, but the way and the purposes for which they are used (Baldassarre *et al*, 2023).

Accordingly, the economic approach is based on the analysis of how different sectors perform in the face of AI (Mo; Ouyang, 2025), presenting both increases in productivity and risks, giving more freedom to employees, and alternative ways of both collecting and processing data. As for social sciences, Baldasserre *et al* (2023, p.363) affirm that “These studies are needed to address potential vulnerabilities and ensure the development of these technologies considers the diverse social contexts and realities in which they are deployed”.

In informatics, sociology, philosophy, and politics, the development of generative models will continue to ignite in-depth discussions on various subjects. These discussions include topics such as regulation, risk mitigation, liability, transparency, and accountability, as well as the effects on socialization patterns and the trajectory of technological development itself (Baldassarre *et al*, 2023).

Within this context, it is important to note that “despite the wide agreement that the latest advances in AI will have disruptive repercussions on the labour market, there is very little evidence for actual integration of AI in the labour market” (Tolan *et al*, 2021). As it is too soon to discern the trends, considering historical trends, the impact of AI on the labour market may be negative, with some undesirable consequences, but the course is yet not set.

3.1 REVOLUTION OF LAW REGARDING TECHNOLOGICAL DEVELOPMENT

Historically, Law is conceived to attend to the necessities of its time, hardly made to prevent or foresee possibilities. It is the product of a need for defense. After the horrors of the Second World War, human rights were catapulted into another dimension, generating new foundations for a world based on equality, raising the question of whether international peace is a product of welfare for the world's citizens or vice versa (Williams, 2025).

Similarly, with the Industrial Revolution, the extensive labor journey, low payments, overpopulation in urban centers, and inhumane conditions of living mobilized the population to discuss salaries and better work conditions. Although industrialization and capitalism have led to better economic outcomes, it also generated an unemployment problem and, consequently,

a growth of external social assistance. Socially, the present population did not follow the establishment of a new era (Polanyi, 2021).

AI appears set on a trajectory that will multiply inequalities, not just in industrialized countries but everywhere around the world. Fueled by massive data collection by tech companies and authoritarian governments, it is stifling democracy and strengthening autocracy (Acemoglu and Johnson, 2024, p. 46).

In this context, observing the changes brought about by generative AI and its implications raises questions about its use and regulation. Shetty *et al* (2025) affirm that “in relation to AI, the regulatory landscape is in a state of constant change and domestically implemented by different governing bodies. These include frameworks based on risk, specific bans, and classification systems”.

Thus, it is possible to understand that a new setting may cause imbalance, but specificity and flexibility are key to regulating its use successfully without impeding progress, and “enhanced international cooperation is necessary to address cross-border AI challenges and harmonize regulatory standards” (Abu-Saqer *et al*, 2024) as well. The current law structure proves insufficient to meet the contemporary demands.

According to Shetty *et al* (2025), “the growing field of AI moderation poses a crucial requirement for assessing the congruence between theoretical frameworks and scholarly forecasts with actual regulatory actions”, which is necessary since the indiscriminate use of AI-based tools results in numerous issues, such as the use of image for criminal purposes, as occurred in 2025, with the arrest of twenty-five people involved in AI generated child pornography (Burgess, 2025).

Hence, using Cost-Benefit Analysis to evaluate the law's applicability and the effects of its outspreads. Sunstein (2018) affirms that “even when it is hard to specify the costs and benefits of a regulation, we might be able to come up with ranges, which can give us enough information to decide if that regulation is worth pursuing”; aiming for the best outcome towards a more balanced and adaptable legal setting regarding digital technologies and generative AI.

The European Commission's proposal for an AI Act was not the first to attempt to introduce or suggest a legal definition of AI, but it has been the most relevant and debated regulatory initiative for the regulation of AI since it was published in April 2021, being the first initiative trying to comprehensively regulate the development and use of AI systems at a supranational level (Castán, 2022).

Within this scope, it is possible to notice that there is a need for an adaptable text, as Gstrein, Haleem, and Andrej (2024) affirm about the AI Act, “this rather general definition will need more interpretation going forward, yet contains a lot of flexibility which might have ultimately been the deciding factor for the legislators”. Since it is impossible to predict all that AI can accomplish and the forms it may take in the future, a malleable approach would be better.

The main challenge for regulation is posed by the fact that AI is not a product that once put on the market does not further evolve during its lifecycle. Moreover, machine learning technologies learn from data, which means that known and unknown challenges in how these systems act are introduced, posing new risk profiles (Cole, 2024).

4 CONCLUSION

Technological development emerges as a structurally transformative force that simultaneously expands economic possibilities and exposes the limitations of existing legal frameworks. As demonstrated throughout this study, emerging technologies not only reshape productive systems and social relations but also challenge the conceptual and operational foundations of Law, revealing a persistent gap between the speed of innovation and the adaptive capacity of legal regulation.

The analysis highlights that this mismatch is not merely technical but deeply rooted in the historical nature of Law. While technological systems tend toward globalization and rapid evolution, legal systems remain largely bounded by national structures and incremental reform logics. As a result, prevailing regulatory approaches based primarily on the adaptation of preexisting norms prove insufficient to address novel and complex technological phenomena.

Moreover, the study reinforces the importance of rejecting deterministic views of technological progress. By recognizing that technological trajectories are shaped by political, economic, and institutional choices, it becomes evident that Law must not only respond to innovation but also actively participate in shaping its direction and distributional consequences. This perspective underscores the centrality of power structures and methodological choices in both the interpretation of technological change and the formulation of legal responses.

In this context, the adoption of diversified methodological approaches proves essential. Descriptive, analytical, and critical frameworks each contribute distinct insights, and their integration enables a more comprehensive understanding of the relationship between Law and technological transformation. Such an approach supports the conception of Law as historically situated, context-sensitive, and inherently interdisciplinary.

Ultimately, addressing the challenges posed by emerging technologies requires more than incremental regulatory adjustments. It demands a reconfiguration of legal thinking itself, one that prioritizes flexibility, adaptability, and methodological plurality. Only through this shift can legal systems move beyond reactive models and develop regulatory frameworks capable of effectively engaging with the complexities of the digital age.

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CREDIT COOPERATIVISM IN BRAZIL: INSTITUTIONAL TENSIONS BETWEEN MUTUALITY, GOVERNANCE, AND MARKET PRESSURES

COOPERATIVISMO DE CRÉDITO NO BRASIL: TENSÕES INSTITUCIONAIS ENTRE MUTUALIDADE, GOVERNANÇA E PRESSÕES DE MERCADO

COOPERATIVAS DE CRÉDITO EN BRASIL: TENSIONES INSTITUCIONALES ENTRE MUTUALIDAD, GOBERNANZA Y PRESIONES DEL MERCADO



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ABSTRACT

This study analyzes the trajectory of credit cooperativism in Brazil, focusing on the tensions between mutuality, governance, and market pressures that shape its contemporary evolution. The research employs a qualitative approach, combining analytical-descriptive narrative review with documentary analysis of institutional reports and specialized literature. Data show that the sector grew by 86% in the number of members between 2019 and 2024, with total assets exceeding R\$ 885 billion and presence in 58% of Brazilian municipalities, consolidating itself as an alternative to the traditional banking system. The analysis identifies three critical axes: (i) mutuality vs. efficiency, highlighting democratic governance and surplus distribution; (ii) regulatory and market pressures, which pose challenges to the cooperative identity; and (iii) socioeconomic impact, particularly in regions with low banking capillarity. The discussion incorporates recent sources to problematize the sustainability of the model in the face of management professionalization and increasing operational complexity. The findings demonstrate that, while credit cooperativism presents concrete competitive advantages, its accelerated growth requires balancing efficiency with the preservation of principles. The research concludes that the institutional stability of the sector depends on the ability to expand scale without undermining mutuality, proposing an agenda for future studies on best governance practices in large cooperatives.

Keywords: Cooperative Governance. Financial System. Financial Institutions. Regional Development.

RESUMO

O presente estudo analisa a trajetória do cooperativismo de crédito no Brasil, com foco nas tensões entre mutualidade, governança e pressões de mercado que moldam sua evolução contemporânea. A pesquisa adota abordagem qualitativa, combinando revisão narrativa analítico-descritiva com análise documental de relatórios institucionais e literatura especializada. Os dados permitem observar que o setor cresceu 86% no número de cooperados entre 2019 e 2024, com ativos totais superando R\$ 885 bilhões e presença em 58% dos municípios brasileiros, consolidando-se como alternativa ao sistema bancário.

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tradicional. A análise identifica três eixos críticos: (i) mutualidade vs. eficiência, com destaque para a governança democrática e a distribuição de sobras; (ii) pressões regulatórias e de mercado, que impõem desafios à identidade cooperativista; e (iii) impacto socioeconômico, especialmente em regiões com baixa capilaridade bancária. A discussão incorpora fontes recentes para problematizar a sustentabilidade do modelo frente à profissionalização da gestão e à crescente complexidade operacional. Os resultados demonstram que, embora o cooperativismo de crédito apresente vantagens competitivas concretas, seu crescimento acelerado exige equilíbrio entre eficiência e preservação de princípios. A pesquisa conclui que a estabilidade institucional do setor depende da capacidade de expandir escala sem descaracterizar a mutualidade, propondo agenda para estudos futuros sobre boas práticas de governança em grandes cooperativas.

Palavras-chave: Desenvolvimento Regional. Governança Cooperativa. Instituições Financeiras. Sistema Financeiro.

RESUMEN

Este estudio analiza la trayectoria de las cooperativas de crédito en Brasil, centrándose en las tensiones entre mutualidad, gobernanza y presiones de mercado que configuran su evolución contemporánea. La investigación adopta un enfoque cualitativo, combinando la revisión narrativa analítico-descriptiva con el análisis documental de informes institucionales y literatura especializada. Los datos muestran que el sector creció un 86% en número de miembros entre 2019 y 2024, con activos totales que superaron los R\$ 885 mil millones y presencia en el 58% de los municipios brasileños, consolidándose como una alternativa al sistema bancario tradicional. El análisis identifica tres ejes críticos: (i) mutualidad vs. eficiencia, destacando la gobernanza democrática y la distribución de excedentes; (ii) presiones regulatorias y de mercado, que plantean desafíos a la identidad cooperativa; y (iii) impacto socioeconómico, especialmente en regiones con baja capilaridad bancaria. La discusión incorpora fuentes recientes para problematizar la sostenibilidad del modelo frente a la profesionalización de la gestión y la creciente complejidad operativa. Los resultados demuestran que, si bien las cooperativas de crédito presentan ventajas competitivas concretas, su crecimiento acelerado requiere un equilibrio entre eficiencia y preservación de principios. La investigación concluye que la estabilidad institucional del sector depende de la capacidad de expandirse sin comprometer la mutualidad, proponiendo una agenda para futuros estudios sobre buenas prácticas de gobernanza en grandes cooperativas.

Palabras clave: Desarrollo Regional. Gobernanza Cooperativa. Instituciones Financieras. Sistema Financiero.

1 INTRODUCTION

In recent decades, the Brazilian financial system has undergone an intense process of banking concentration, resulting in the consolidation of large financial conglomerates and a high concentration of the Brazilian banking market, a phenomenon widely documented in the sectoral literature (FEBRABAN, 2024). In parallel with this movement, there was a continuous expansion of credit unions as an institutional alternative aimed at democratizing access to financial services, especially in regions less served by traditional banking institutions (BANCO CENTRAL DO BRASIL, 2024).

In Brazil, credit unions are regulated by Law No. 5,764/1971, which establishes the National Cooperative Policy, as well as by Complementary Law No. 130/2009, which specifically provides for the National Cooperative Credit System. The prudential supervision of these institutions is exercised by the Central Bank of Brazil.

Credit unions are singular financial institutions, organized in a cooperative corporate form, in which the users of financial services are simultaneously owners of the organization, participating in its management through a democratic structure based on the principle of "one member, one vote", regardless of the subscribed capital (PINHEIRO, 2008). Such an institutional arrangement reduces agency costs and classic asymmetries between ownership and use of the service, as highlighted by Hansmann (1996) in the economic theory of cooperative organizations.

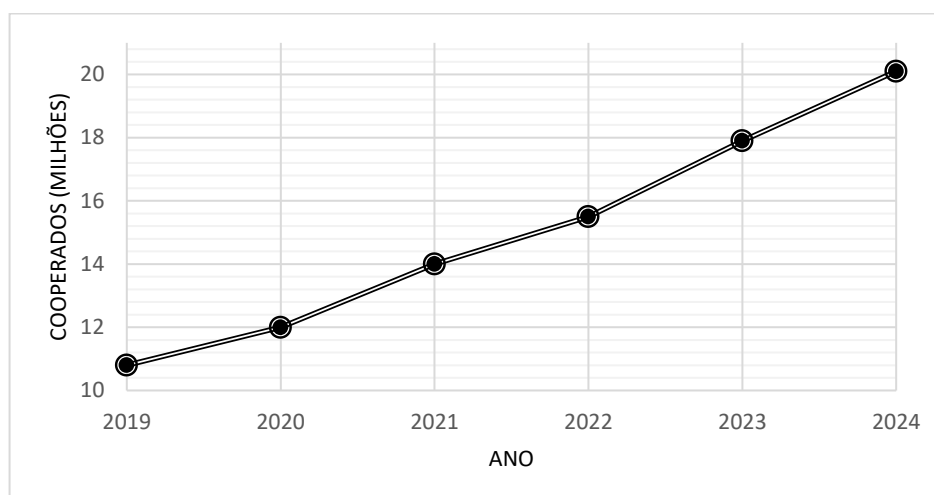
This characteristic substantially differentiates these institutions from traditional commercial banks, whose governance is primarily oriented towards maximizing shareholder returns.

In Brazil, credit cooperativism has reached a prominent position in the National Financial System, bringing together approximately 20 million members, assets of more than R\$ 885 billion and presence in about 58% of Brazilian municipalities, with a growing participation in national financial intermediation (BCB, 2024). Brazil has 4,509 cooperatives, 700 of which are in the credit sector. This growth shows not only quantitative expansion of the sector, but also the strengthening of an institutional model based on mutuality, economic redistribution, and regional development (BNDES, 2025).

This expansion can be seen in Figure 1, which shows a growth of approximately 86% in the number of cooperative members between 2019 and 2024, evidencing the growing adherence of the Brazilian population to the cooperative model of financial intermediation.

Figure 1

Evolution of the number of cooperative members in the SNCC (2019 – 2024)



Source: Prepared by the author based on OCB (2025) and the Central Bank of Brazil (2025).

Among the main credit cooperative systems in Brazil, the following stand out: Sicoob, Sicredi, Cresol and Unicred, with the three largest totaling 18 million members (BORGES, 2022). In addition to their economic function, credit unions play an important social role by promoting financial inclusion, fostering small businesses, stimulating local entrepreneurship and redistributing economic results to their members through the annual return of net surpluses, a mechanism that does not exist in the traditional banking model (BIALOSKORSKI NETO, 2012).

The search for equity, solidarity, and self-sufficiency have marked the history of these institutions since the Industrial Revolution in England in the nineteenth century, when workers in precarious working conditions came together in mutual aid societies. Voluntary membership, democratic management, and equitable distribution of benefits are the fundamental principles that guide cooperativism (SANTOS, 2024).

In this context, the present study aims to analyze the historical evolution of credit cooperativism, with emphasis on its consolidation in Brazil, as well as to discuss the institutional, economic and social foundations that explain the growing competitiveness of cooperative banks compared to the traditional banking system. In this sense, this analysis is not limited to describing the evolution of credit cooperativism, but seeks to highlight the tensions that accompany its growth, especially those related to its adaptation to the dynamics of the traditional financial system, leading to the guiding question: to what extent does the recent expansion of credit cooperativism in Brazil strain its mutualist foundations in the face of governance requirements and financial market pressures?

2 METHODOLOGY

The present study has a qualitative nature, developed through a narrative review with an analytical-descriptive approach, complemented by documentary analysis. Indexed scientific articles, specialized works on cooperativism, official reports of the Central Bank of Brazil, documents of the Organization of Brazilian Cooperatives and institutional publications of the main credit unions operating in the country were used as sources. The selection of sources considered criteria of thematic relevance, timeliness, and adherence to the object of study.

The analysis of the information allowed us to infer about the evolution of the number of service stations and the number of cooperative members in Brazil between the years 2019 and 2024, as well as the number of singular cooperatives. In addition to the descriptive analysis, we sought to adopt an interpretative approach oriented to the identification of tensions between the cooperative foundations and the contemporary management practices of these institutions, based on the graphic analysis of the observed trends. This perspective allows us to go beyond the description of the phenomenon, incorporating analytical elements related to governance, control mechanisms and the economic rationality underlying the performance of credit unions in the current context.

3 HISTORICAL FOUNDATION OF COOPERATIVISM

The origin of modern cooperativism is associated with the economic and social transformations triggered by the European Industrial Revolution, especially in nineteenth-century England, a period characterized by the precariousness of labor relations, concentration of income, and economic exclusion of large segments of the working population (PORT, 2022).

In this context, pioneering experiences of collective organization aimed at economic self-sufficiency stand out, culminating in the foundation of the Society of Pioneers of Rochdale, in 1844, considered a historical landmark of modern cooperativism, with voluntary membership, democratic management, economic participation of members, and interest in the community (ACI, 2022).

Parallel to the development of consumer cooperatives, the first structured experiences of financial cooperativism emerged in Germany, consolidating the foundations of contemporary credit cooperativism. The idealized model had the following characteristics: (1) the company's capital was constituted through shares paid in by the members, under the principle of self-help; (2) there was the constitution of a reserve fund generally limited to ten percent of the subscribed capital; (3) distribution of gains among the partners in the form of dividends; (4) joint and

unlimited liability of the partners for the entity's business; (5) as it was not a class association, the participation of all economic categories was allowed (PINHEIRO, 2008).

These models directly influenced the international expansion of financial cooperativism and served as a reference for the subsequent implementation of credit unions in several countries, including Brazil (WOCCU, 2024).

4 EVOLUTION OF CREDIT COOPERATIVISM IN BRAZIL

The Brazilian credit cooperativism formally began in 1902, with the foundation of the Amstad Savings and Loans Bank, in the municipality of Nova Petrópolis, Rio Grande do Sul, by the Jesuit priest Theodor Amstad. Inspired by the Raiffeisen model, this institution is recognized as the first credit union in Latin America (PINHEIRO, 2008).

During much of the twentieth century, the growth of the sector occurred gradually, initially restricted to specific niches, especially rural communities and agricultural cooperatives. However, from the 1990s onwards, with the regulatory modernization promoted by the Central Bank of Brazil and the progressive structuring of integrated cooperative systems, there was a significant expansion of the sector.

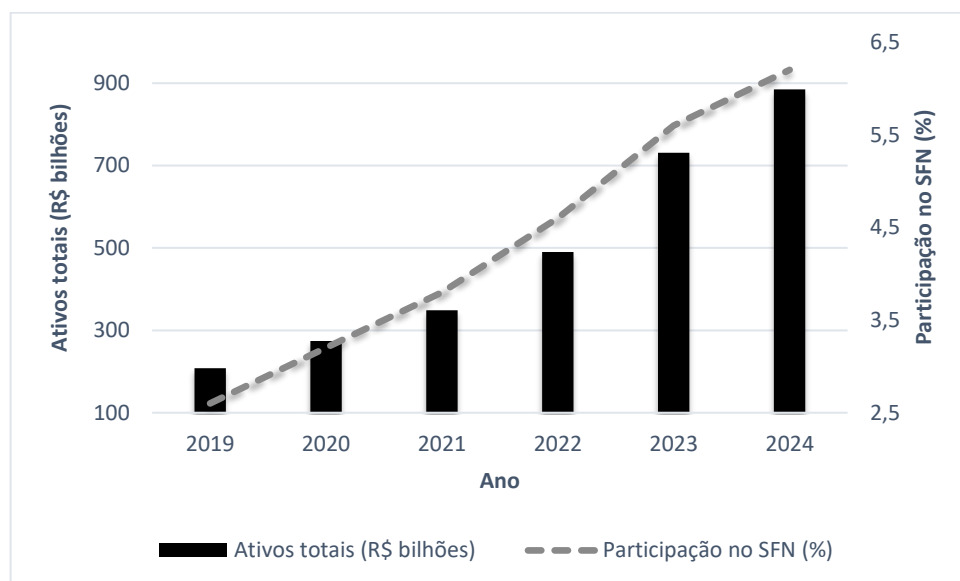
The enactment of Complementary Law No. 130/2009 represented a relevant regulatory milestone by disciplining the National Cooperative Credit System and increasing the legal and operational security of Brazilian credit unions, contributing decisively to their professionalization and institutional expansion.

The path forward for cooperative banks in sustainability will be intrinsically linked to the evolutionary path of their main customers, that is, small entrepreneurs, families and local communities (BEVILACQUA, 2022). An expressive innovative act took place in 2025, with the publication of two resolutions by the Central Bank of Brazil (BCB) and the National Monetary Council (CMN), regulating the Brazilian financial system: Joint Resolution No. 14/2025, which changes the way the minimum capital required of financial institutions — including credit unions — is calculated, replacing the previous model, based only on the type of institution, by a new calculation proportional to the activities actually performed. The purpose was to strengthen the soundness of the financial system, mitigate risks, and ensure treatment proportional to the size and complexity of each institution (BCB, 2025).

The sector's equity growth evidences its structural expansion in the Brazilian financial market. As shown in Figure 2, the total assets of the National Cooperative Credit System grew more than four times between 2019 and 2024, accompanied by a continuous expansion of its relative participation in the National Financial System.

Figure 2

Evolution of total assets and participation of credit unions in the National Financial System (2019–2024)



Source: Prepared by the author based on the Central Bank of Brazil (2024; 2025).

The graphical analysis shows that the expansion of the Brazilian credit cooperativism has a structural and sustained character. Between 2019 and 2024, there was significant growth both in the number of cooperative members and in the volume of total assets managed by the sector, accompanied by a continuous expansion of its relative participation in the National Financial System. Such indicators are compatible with the hypothesis of institutional strengthening and growing competitiveness of credit unions in the Brazilian financial market (SOUZA, 2024).

Part of the literature points out that the recent expansion of credit unions is not exclusively due to its institutional advantages, but also to regulatory asymmetries and specific conditions of the financial system that favor this movement (FERRI; KALMI; KEROLA, 2014).

The evolution has been observed markedly in European countries, with the adhesion of 52 million members to Credit Agricole (Caisse Nationale de Crédit Agricole) in France, 17.7 million in Germany, members of DZ Bank (German Central Cooperative Bank) in Germany, constituting cooperative banks with high credibility in the market.

The Crédit Agricole Group is called "the green bank" due to its historical links with agriculture. It is a French international banking group and the largest cooperative financial institution in the world. It is the second largest bank in France, and the third largest in Europe and the tenth largest in the world, and considered a bank of systemic importance by the Financial Stability Board (MEINEN and PORT, 2016).

DZ Bank AG is the second largest bank in Germany in terms of assets and the central institution for around 700 cooperative banks and their approximately 7,200 branches, and due to its volume of funding it is directly supervised by the European Central Bank (EUROPEAN CENTRAL BANK, 2023).

5 COMPETITIVE ADVANTAGES OF CREDIT UNIONS OVER THE TRADITIONAL BANKING SYSTEM

Unlike commercial banks, whose main purpose is to maximize shareholder returns, credit unions operate according to a mutualist logic, oriented to the efficient provision of financial services to their members. In this model, users are simultaneously customers and owners of the institution, reducing classic agency conflicts and promoting greater alignment between institutional interests and the needs of the cooperative members (BIALOSKORSKI NETO, 2012).

One of the main competitive advantages observed lies in the practice of interest rates and fees that are generally more attractive when compared to traditional banking institutions. This is because cooperatives do not need to remunerate external shareholders, allowing greater distributive efficiency in the allocation of economic results generated by financial activity (MENEZES; CROCCO, 2014).

Additionally, at the end of each fiscal year, any net surpluses calculated after the constitution of legal and statutory reserves can be distributed among the cooperative members according to their economic movement with the institution, a mechanism that reinforces the character of collective return and structurally differentiates the cooperative model from the traditional banking model (PINHEIRO, 2008).

The definition of performance indicators starts to play a central role in this process. When guided exclusively by economic and financial results, they tend to bring cooperatives closer to the traditional banking logic. On the other hand, when they incorporate dimensions related to inclusion and collective benefit, they can contribute to preserving the cooperative identity (VILELA, 2024).

Another aspect of emphasis refers to the territorial capillarity of credit unions, especially in small and medium-sized municipalities often neglected by private banking institutions. In several cases, such cooperatives represent the only financial institution physically present in certain locations, contributing to the financial inclusion of populations historically not served by the conventional banking market (BANCO CENTRAL DO BRASIL, 2024).

From a regional macroeconomic perspective, several studies indicate that the resources raised by cooperatives tend to remain in greater proportion in local economies, being reinvested in the community itself through credit operations, productive financing and support for regional entrepreneurship. Such dynamics generate a multiplier effect on income, employment and local economic development (MENEZES; CROCCO, 2014).

Although the competitive advantages of credit unions are widely recognized, especially with regard to distributive efficiency and financial inclusion, it is important to consider that such advantages are not static. As cooperatives expand their scale and operational complexity, part of these differentials can be gradually reduced, especially when there is the incorporation of management structures and strategies typical of traditional banking institutions. In this sense, the competitive advantage of the cooperative model should be understood as a dynamic equilibrium, and not as a permanent condition (CHAVES, 2009).

Nevertheless, it is important to recognize that credit unions also have competitive limitations compared to large commercial banks, especially with regard to operational scale, technological investment capacity and breadth of portfolio of complex financial products. Such limitations have been progressively mitigated by the consolidation of integrated cooperative systems and the growing professionalization of the management of these institutions.

Table 1 presents the main characteristics inherent to credit unions in comparison to the banking network.

Table 1

Structural comparison between credit unions and traditional banks

CRITERIA	CREDIT UNIONS	TRADITIONAL BANKS
Property	Associates/Cooperatives	Shareholders
Right to vote	1 member = 1 vote	Proportional to actions
Economic purpose	Collective benefit	Profit
Distribution of results	Leftovers for cooperative members	Dividends to shareholders
Fees/Fees	Usually smaller	Generally larger
Territorial focus	Regional/Local	National/International
Financial inclusion	Relatively high	Moderate
Sophisticated portfolio	Moderate	Elevated

Source: Prepared by the author based on Bialoskorski Neto (2012), Pinheiro (2008) and the Central Bank of Brazil (2024).

The annual distribution of surpluses is a maxim in the cooperative sector. At the end of each year, accountability meetings are held to the members and the destination of the surpluses is put to a vote. Deposits in credit unions are protected by the Credit Cooperative Guarantee Fund (FGCoop). This fund guarantees deposits and credits held in individual credit unions and cooperative banks in the event of intervention or extrajudicial liquidation of these institutions.

Currently, the limit value of this protection is the same as that in force for bank depositors (BCB, 2025).

It is observed that the efficient management system results in the generation of annual results, with the retention of a part for reserves and the rest is distributed according to the participation of each member in the use of financial services and in the individual capital invested.

6 SOCIOECONOMIC IMPACT AND REGIONAL DEVELOPMENT

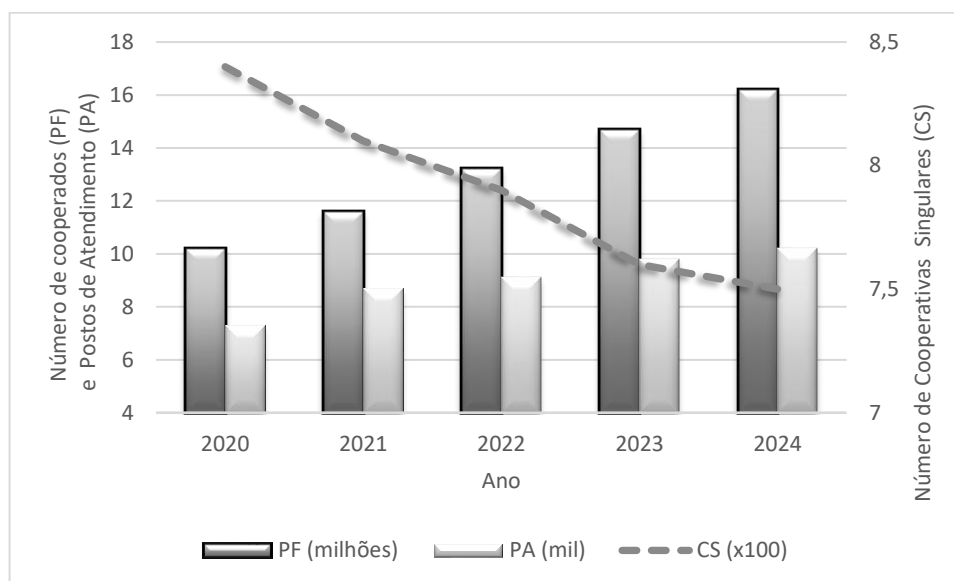
In addition to their financial function, credit unions play an important role as instruments of regional socioeconomic development. Their performance transcends mere financial intermediation, inserting themselves in an institutional logic oriented to strengthening the communities in which they are established.

The cooperative principle of interest in the community, consolidated by the International Cooperative Alliance, translates into the recurrent implementation of financial education programs, support for local entrepreneurial initiatives, promotion of social projects, and encouragement of citizenship and economic training of its members (ACI, 2022).

In the Brazilian context, especially in smaller municipalities with a strong agricultural vocation, credit unions play a leading role in financing productive activity, supporting agribusiness and stimulating the formalization of small businesses, contributing directly to the generation of employment, income and municipal tax collection. The number of cooperative members in the period from 2020 to 2024 can be seen in Figure 3.

Figure 3

Evolution of the number of individuals (PF), service stations (PA) and number of singular credit unions (CS) in Brazil in the period from 2020 to 2024.



Equations: (PF): $y = 1.51x + 8.65$; (PA): $y = 0.69x + 6.95$; (CS): $y = -0.23x + 8.59$

Source: Prepared by the author based on the Central Bank of Brazil (2025).

It can be observed that in the period studied there was an increase of 58.8% in the number of cooperative members (individuals) and 39.7% in the number of service stations. Such action reveals that credit cooperativism is not limited to representing an alternative model for the provision of financial services, but can be an important mechanism for endogenous regional development, capable of reducing territorial asymmetries in access to credit and promoting greater economic decentralization. There was a decrease in the number of singular cooperatives by incorporation into central cooperatives, and thus from 847 cooperatives in 2020, there were 753 in 2024. Thus, the number of cooperative members (PF) per cooperative (CS) was 12,042 in 2020 and increased to 21,514 in 2024.

Despite the relevant role of credit unions in regional development, the effectiveness of this impact depends on the way resources are allocated and the strategies adopted by the institutions themselves. Not all credit expansion necessarily implies sustainable local development, and it is essential to analyze the quality of operations, the profile of the beneficiaries and the capacity to retain value in regional economies. Thus, the socioeconomic impact should not be assumed, but continuously evaluated in light of concrete evidence and performance criteria (MANENTI, 2022).

Similar findings are observed internationally in studies on European cooperative banks, which demonstrate greater local retention of resources and greater regional credit stability (FERRI; KALMI; KEROLA, 2014).

7 DISCUSSION

Cooperativism is an economic and social system in which cooperation is the basis on which economic activities are built. This consists of the primacy of people in the economy and the cooperation of all to achieve the common good (GOLOS, 2025). At the same time, it is observed that the growth of credit unions in Brazil stems from the comparative institutional advantages of the cooperative model in contexts of banking concentration and regional financial exclusion (FEBRABAN, 2024).

Although often associated with the democratization of access to credit and the strengthening of regional development, the expansion of credit unions also raises relevant questions about the sustainability and coherence of the model over time. Accelerated growth, especially in environments of high banking concentration, may indicate not only the consolidation of an institutional alternative, but also a process of adaptation to the same market logics that historically characterize the traditional financial system. In this sense, the analysis of cooperativism cannot be restricted to its declared social function, and it is necessary to understand how this model responds to the pressures for efficiency, scale, and competitiveness (BNDES, 2025).

The combination of democratic governance, economic redistribution, territorial capillarity, and alignment between user and owner of the institution gives cooperatives structural advantages that are difficult to replicate by the traditional banking system.

However, the advancement of the sector also imposes relevant challenges. The growing professionalization of management, the expansion of operational scale and the increase in regulatory complexity may induce the progressive mischaracterization of the original cooperative model, especially when large cooperatives start to adopt complex managerial practices and organizational structures.

This phenomenon, often called "banking of cooperativism", constitutes one of the main contemporary challenges of the sector, as it generates tension between economic efficiency and preservation of the founding cooperative principles. From the perspective of controllership, this tension becomes even more relevant, because the institutional growth of cooperatives requires increasingly sophisticated management, control and performance evaluation instruments. The problem is that the adoption of these practices, although necessary to ensure efficiency, sustainability, and regulatory compliance, can also reinforce a rationality guided by economic and financial results to the detriment of the centrality of the cooperative (ZHAO et al., 2026). Thus, the more the organization expands scale, professionalizes management and incorporates performance metrics typical of the conventional financial system, the greater the

risk of weakening its cooperative differentiation. It is observed that the challenge is not only to grow, but to do so without converting the mutualist logic into mere institutional rhetoric. This phenomenon associated with the expansion of scale and the complexification of the governance of large cooperatives was also discussed by Birchall (2014) in studies on large international cooperative organizations.

In the present work, the trends observed indicate the continuity of the cooperatives' expansion process, if the structural conditions are maintained.

8 FINAL CONSIDERATIONS

The historical and institutional analysis of credit cooperativism shows that its consolidation in the Brazilian financial system results from the combination of classic cooperative fundamentals, organizational efficiency and growing professionalization of management.

The sector ceased to represent a peripheral alternative restricted to specific niches to assume a strategic position in the National Financial System, progressively expanding its market share and socioeconomic relevance (FEBRABAN, 2024).

The mutualist nature of credit unions constitutes their main structural differential in relation to the traditional banking system, since the convergence between user and owner of the institution reduces agency conflicts, favors greater alignment of economic incentives and allows for a more equitable redistribution of the results generated by financial activity (HANSMANN, 1996).

In addition, international experience shows that financially robust cooperative systems tend to be more resilient in scenarios of systemic crisis, reinforcing the strategic importance of these institutions for the stability of the financial system as a whole (FERRI; KALMI; KEROLA, 2014).

A relevant agenda for future studies is to analyze, in a more in-depth way, concrete experiences of cooperatives that have managed to grow without losing adherence to their principles, identifying practices that can be replicated in other contexts, considering that currently two credit unions occupy the seventh and eighth place in the ranking of Brazilian banks by total assets.

It is concluded, therefore, that credit unions represent not only a competitive alternative to the traditional banking model, but also an important instrument for regional economic development and strengthening of financial citizenship. Its sustainable growth will depend on

the ability to expand scale and efficiency without renouncing the cooperative principles that have historically underpinned its legitimacy and institutional differentiation.

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IMAGES OF CONTROL OVER BLACK WOMEN IN THE TV SOAP OPERA VALE TUDO (2025)

IMAGENS DE CONTROLE SOBRE AS MULHERES NEGRAS NA TELENÓVELA “VALE TUDO” 2025

IMÁGENES DE CONTROL SOBRE LAS MUJERES NEGRAS EN LA TELENÓVELA VALE TUDO (2025)



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ABSTRACT

This study aims to analyze the representations of the characters Raquel Acioli and Maria de Fátima from the soap opera Vale Tudo (2025), considering the dialogue with Black feminist discussions on images of control (COLLINS, 1990). The discussion established a relationship between the ways these Black women are represented in the soap opera and the stereotypes associated with this social group. The intention is to promote debate about the relevance of soap operas in addressing social issues and about the social imaginary that has been constructed around Black women.

Keywords: Soap Opera. Black Feminism. Images of Control.

RESUMO

O presente trabalho visa analisar as representações das personagens Raquel Acioli e Maria de Fátima, da telenovela “Vale Tudo” (2025), tendo em vista o diálogo com as discussões do feminismo negro sobre as imagens de controle (COLLINS, 1990). Na discussão, foi estabelecida a relação entre as formas de representar essas mulheres negras na novela, com os estereótipos relacionados a esse grupo. A intenção é levantar o debate sobre a relevância da telenovela na abordagem de questões sociais, e sobre o imaginário que tem sido construído socialmente sobre as mulheres negras.

Palavras-chave: Telenovela. Feminismo Negro. Imagens de Controle.

RESUMEN

El presente trabajo tiene como objetivo analizar las representaciones de los personajes Raquel Acioli y Maria de Fátima de la telenovela Vale Tudo (2025), considerando el diálogo con las discusiones del feminismo negro sobre las imágenes de control (COLLINS, 1990). En la discusión, se estableció la relación entre las formas de representar a estas mujeres negras en la telenovela y los estereotipos asociados a este grupo social. La intención es

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promover el debate sobre la relevancia de la telenovela en el abordaje de cuestiones sociales y sobre el imaginario que se ha construido socialmente acerca de las mujeres negras.

Palabras clave: Telenovela. Feminismo Negro. Imágenes de Control.

1 INTRODUCTION

The *remake* of the telenovela "Vale Tudo", from 2025, brought as one of the proposals for the plot a more diverse cast, which made the plot adopt more black characters, including in the central core. In this way, the characters of the axis of protagonists, Raquel Acioli and Maria de Fátima Acioli, were played by black actresses, Taís Araújo and Bella Campos, respectively.

However, despite the difference in the approach, the *remake* generated discussion, since the representativeness proposed by the inclusion of black characters did not materialize as it should. In addition to the erasure of the characters in the plot, mischaracterizing their importance compared to the original version of the 1988 telenovela, the representation of the characters was built on stereotyped bases.

According to Collins (1990), in a thought about the stereotypes that are addressed to black American women (which can extend to black women of other cultures), the images of the *mammy*, the matriarch, the mother dependent on the State and the Jezebel/"hot" are common. Such stereotypes reveal images of control over this group, that is, the attribution of negative standards on black women regarding the ways of being, acting and being in the world. Understanding this phenomenon is of great interest to black feminist thought today, with a view to breaking with the perpetuation of reductionist and harmful images of black people. In this line, transposing this concern to the analysis of communicational products, as is the case of the soap opera, it is intended to verify if, and which control images may be involved in the representations of the characters Raquel and Maria de Fátima, from "Vale Tudo" (2025).

Given the presence of black women in leading roles, and in a prominent soap opera, it is pertinent to analyze how the representation of these characters took place. Thus, the present work proposes, from the perspective of control images, to trace initial reflections on which meanings were attributed to the characters Raquel and Maria de Fátima, with the intention of understanding how the socially constructed images about black women have currently been worked on by the media, specifically in soap operas.

2 CONTROL IMAGES

The historical process of oppression in various spheres (family, institutional, etc.) of black women, and the consequent subordination of the female role in society, is pointed out by Collins (1990). According to the author, it is these dominations that affect the construction of a social conscience, and policies aimed at black women. Consequently, this process derives the reinforcement of white supremacy and the construction of stereotyped images about black

women, aiming to control issues of gender, race, sexual orientation, beauty standards and behavior.

Collins (1990) draws attention to the discussions about the attribution of the condition of "other" to black women, that is, as the opposite and negative part of a binary relationship. The objectification and domination, arising from this unequal relationship, lead to the creation of images of control over black women, which are perpetuated in society.

In this sense, the construction of the image of black women serves to maintain the power of hegemonic groups, and is manifested by stereotypes that are maintained, albeit with some updates. Collins (1990) explains that the main images of control studied by black feminism are: *mammy*, the matriarch, the mother who is dependent on the State and Jezebel.

In the control image of the *Mammy*, the idea is of an obedient and faithful servant, a kind of mother of the white family. That is, a black woman who serves a white family, and who despite any space she has in this circle, is subordinate. This influences the permanence of oppression, with the attribution of the role of care and deference to white groups as a value and a duty. In addition, black women have their preferences, subjectivities and sexual issues annulled, as they live according to those they serve (COLLINS, 1990).

The image of the matriarch refers to the mother of the black family, a woman characterized as alone, abandoned by her partner, and without qualities, such as femininity. Her existential conditions are often passed on to her children, perpetuating poverty and other negative issues, making her a failure. Such a simplistic perspective blames women, maintaining the ideal of patriarchy, and ignores the social, historical, economic and political conditions that involve black existence (COLLINS, 1990).

According to Collins (1990), regarding the image of women dependent on the State, the notion is that by requesting the right to help from social programs, black women are accommodated with the situation of vulnerability, leaving their children also lazy, without cultivating the value of work. In this way, the black women of this group are failures to the extent that they are alone, because in general they are not in a family in the patriarchal mold, and only burden the State, since they do not work.

Finally, the Jezebel control image, or *Hoochie* (related to the promiscuous woman), portrays the black woman as sexually aggressive, or with deviant sexuality, when she escapes heteronormative standards. From this stereotype, derives the idea of the woman who relates for financial interest, who seduces and deceives (COLLINS, 1990).

Thus, as Collins (1990) points out, such images of control act to perpetuate the power of heterosexual white men, and in the same way, to maintain oppressions of race, gender, class,

sexual orientation, etc. Therefore, it is of paramount importance to recognize these images and act in the construction of other imaginaries. As the media acts in this process of creation and/or reaffirmation of values on various social issues, and the soap opera is an important cultural product for this objective, the communicative potential it can have in society will be studied below.

3 THE TELENOVELA "VALE TUDO": 2025 REMAKE

The first version of the telenovela "Vale Tudo" aired on TV Globo in 1988 and was written by Gilberto Braga, Aguinaldo Silva and Leonor Bassères. Due to the great success of the plot, the network produced the *remake* of the soap opera in 2025, which was adapted by author Manuela Dias. The main plot discusses the limits of honesty and greed, bringing social, moral and ethical reflections from the opposition between the heroine Raquel Acioli (Taís Araújo) with her own daughter, the unscrupulous Maria de Fátima (Bella Campos), and also with the villain Odete Roitman (Débora Bloch).

The soap opera, as a rich media product for the debate on Brazilian culture and identity (LOPES, 2014), when updated, as "Vale Tudo" in *remake*, expands the possibilities of discussion, covering another historical context. Thus, in the 2025 version, the soap opera drew attention for adopting the *Merchandising* social (a way of approaching different current themes in a pedagogical way in the plot) when dealing with topics such as alimony, homosexual relationships, adoption, ageism and sexual orientation.

In addition, it was proposed to include black actors/actresses to occupy the roles that in the original version of the soap opera were white people. Some of the updates were: Raquel Acioli (Taís Araújo); Maria de Fátima (Bella Campos); Sardinha (Lucas Leto); Luciano (Licínio Januário); Jarbas (Leandro Firmino); Consuelo (Belize Pombal); Daniela (Jessica Marques); André (Breno Ferreira); Fernanda (Ramille) and Eunice (Edvana Carvalho). In this way, the current version of "Vale Tudo" included black characters for the main and supporting cast, unlike the original version, which brought only two black characters throughout the plot: Gildo (Fernando Almeida), who was a street kid, later welcomed by Raquel, and Zezé (Zeni Pereira), the maid of Ivan's family.

In the case of Raquel and Maria de Fátima, the casting of black actresses for the roles proved to be an opportunity to bring black protagonism to the plot, however, in addition to the presence of black people in the soap opera, it is interesting to verify to what extent the representativeness was materialized, and how the construction of the characters took place.

Thus: what meanings were attributed to Raquel and Maria de Fátima, and in what way do they reinforce or innovate in the images that are socially constructed about black women?

Therefore, the choice is to analyze the representations of the characters Raquel Acioli and Maria de Fátima. The characters were chosen because they are part of the core of protagonists, in the current version played by black actresses, and because they contain, in the narrative arc, events that give rise to the intended analyses. Reflecting on the ways of constructing meaning about such prominent characters in the soap opera can help to understand which images are (still) constructed about black women, and which are passed on to the soap opera audience.

For the analysis, excerpts from the soap opera were chosen that demarcate the rupture between Raquel and Fátima, which appears in the initial chapters of the soap opera. The passage covers the initial position of the characters (both living in Foz do Iguaçu), a fact that impels them to act (the sale of the house), and their arrival in Rio de Janeiro. With this excerpt from the soap opera, the process of presentation and at the same time reconstruction of the characters is evidenced, and the framing of the character of both, with values and attitudes that will accompany their entire narrative arc until the end of the plot. From such events, which highlight the contrast between the characters, the intention is to verify how the representation of the black woman took place, considering the discussions about the images of control.

4 IMAGES OF CONTROL ON STAGE: THE CHARACTERS RAQUEL ACIOLI AND MARIA DE FÁTIMA

Raquel Acioli is represented in "Vale Tudo" as a strong, hardworking woman who cultivates values such as honesty and nurtures unwavering hope for a better life. The plot begins with Raquel living in Foz do Iguaçu with her father and daughter Maria de Fátima. While Raquel works as a local tour guide, Fátima wants to get out of the city and try her luck in Rio de Janeiro, investing in a career in *Influencer* digital, or trying to win a partner rich enough that you don't have to work.

In the first chapter of the novel, on Fátima's twenty-third birthday, Raquel is excited, while her daughter, pessimistic about life in Foz do Iguaçu, regrets having been born poor and wants to leave the city. During the party, Fatima goes to the gate of the house and begins to remember facts that make her dislike her condition. In the memory, the origins of her family are rescued, when Raquel was still married to Rubinho, and faced difficulties due to the irresponsible condition of her partner. On a day when Rubinho comes home drunk in the morning, Raquel

confronts him to take responsibility, work and help with the bills; he becomes enraged and slaps Raquel in the face, who quickly retaliates and says she will leave.

Figure 1

After being assaulted by her husband, Raquel decides to leave with her daughter



Source: Frame from the soap opera Vale Tudo. (Chapter 1, Scene 05' 02").

Raquel cries, lamenting the difficulties suffered in terms of finances and her relationship with Rubinho. However, because he acted immediately to the aggression, retaliating physically and verbally, he imposes his firm position in the face of adversity and assumes an active posture.

Figure 2

Raquel and Fatima talk



Source: Frame from the soap opera Vale Tudo. (Chapter 1, Scene 06' 25").

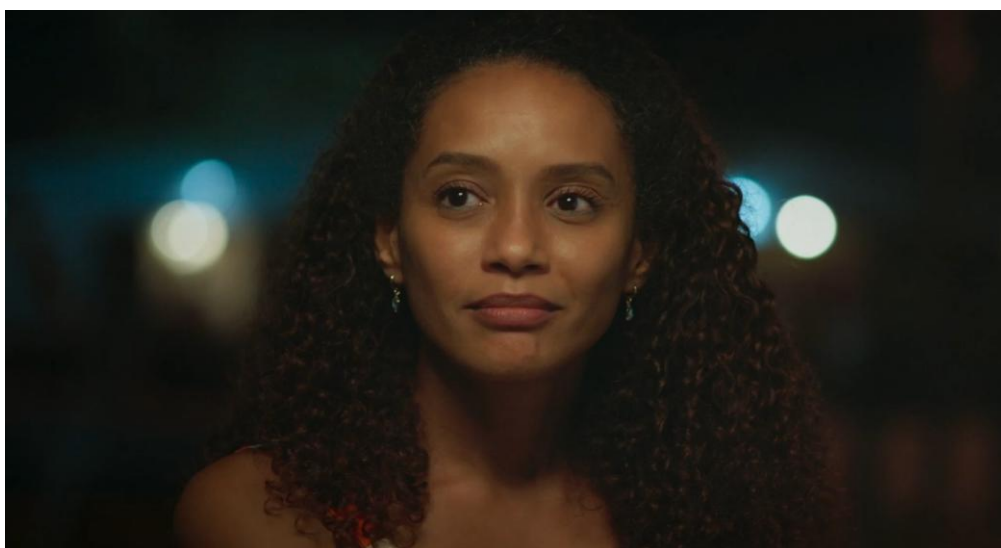
After the memory, Fátima is even more resigned to changing her life, while browsing the social networks of rich people who display a life of luxury. Raquel approaches, and the panoramic image shows the two talking in front of a humble house, on a street that is also

simple, demonstrating the socioeconomic conditions of the family, which contrast with what Fatima dreams of. The mother tries to cheer up her daughter, but the young woman directs the conversation to the case of a rich tourist, but married and already elderly, who tried to get closer to Raquel. She encourages her mother to have an affair with the man so that the two can ascend socially.

Raquel is upset with Fatima's speech, and later, in conversation with a friend, reveals that her hope is in work, and that all prosperity can only come from individual effort. She comments that she wants to open her own business, since this is a current trend, and believes that it will be a good investment. Asked about love relationships, Raquel recalls what she went through with her ex-husband, emphasizing that she managed to be strong and overcome the troubles of the relationship, and points out that to be interested in another man again, she wouldn't even be able to say what kind of man it would be.

Figure 3

Raquel is dreamy with expectations of the future



Source: Frame from the soap opera Vale Tudo. (Chapter 1, Scene 09' 05").

In this way, the representation made of mother and daughter highlights the contrast between the two. Dreams for the future and the notion of values are discrepant. Raquel is the good-hearted girl, with positive thoughts and full of good intentions, and Fatima is the self-interested villain, unscrupulous, and whose values are individualism and materialism.

The distance between mother and daughter continues, as the daily life of the characters is developed. Raquel works as a tour guide, always being very communicative, with a cheerful face, and showing that she likes what she does; meanwhile, Fatima tries to take advantage of her mother's condition to attend a club with tourists.

Figure 4*Fatima sees César for the first time at the club*

Source: Frame from the soap opera Vale Tudo. (Chapter 1, Scene 13' 41")

In one of the incursions through the club, pretending to have a high social status, Fatima sees César, a model who was working at the place, and becomes interested in him. In the scene, Fatima performs a typically masculine gesture of briefly removing a crack in her glasses to better see the one who interested her physically.

After pretending a coincidence at the bar, and inventing lies about her socioeconomic condition, Fatima manages to attract César's attention, and soon after seduces him, spending the night with him.

Figure 5*Fatima and César spend the night together*

Source: Frame from the soap opera Vale Tudo. (Chapter 1, Scene 30' 32")

Later, Raquel receives the news of her father's sudden death. With another load of suffering, she tries to get back on her feet, now that the only male figure she had to support no

longer exists. Raquel is sad and shaken, being comforted by a friend, while Fatima seems only a little dejected, but without suffering.

Figure 6

Raquel suffers in farewell to her father



Source: Frame from the soap opera Vale Tudo. (Chapter 1, Scene 40' 30")

After her grandfather's death, Fátima takes advantage of the fact that the house was in her name and sells the property, using the money to go live in Rio de Janeiro. When she discovers that her father's house has been sold, Raquel is desperate, but she does not believe her daughter's bad nature.

Figure 7

Raquel is shaken when she discovers that Fatima sold the house

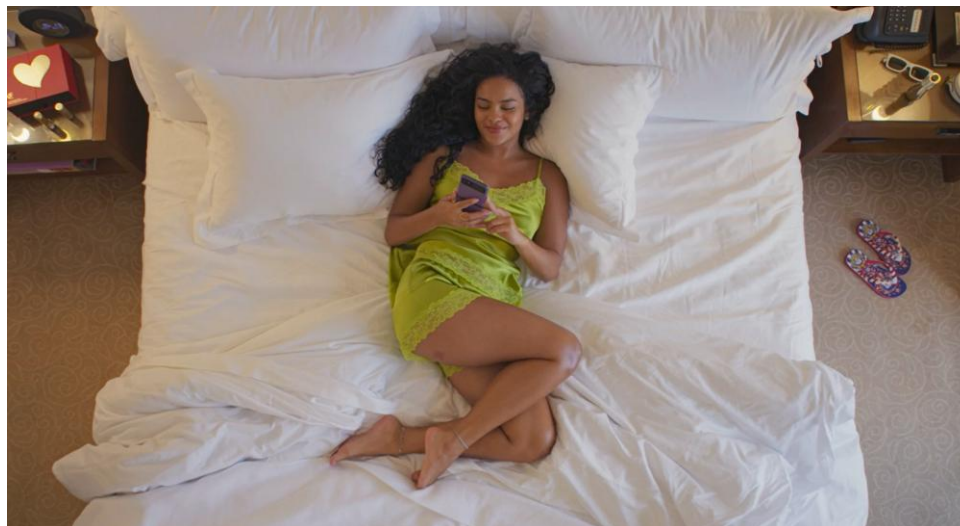


Source: Frame from the soap opera Vale Tudo. (Chapter 1, Scene 48' 54").

While Raquel tries to go to Rio de Janeiro, buying a bus ticket to the city and quitting her job, Fatima stays at the Copacabana Palace and keeps the lies about her financial condition to César.

Figure 8

Fatima takes advantage of Rio de Janeiro and makes an appointment with César



Source: Frame from the soap opera Vale Tudo. (Chapter 3, Scene 01' 34").

In the representation of the characters, Raquel is always humble, kind and honest. In characterization, she is usually dressed in simple and colorful clothes (which shows both her personality and her financial condition), and has a general appearance that shows that she does not care about issues related to femininity. Endowed with values aimed at life dignified by work and individual effort, she is fervent in the ideas she defends, and fights to support herself and also take care of her daughter, since difficult circumstances have crossed her life, such as a marriage permeated by financial instability and disrespect. With the death of her father and the departure of her daughter, Raquel once again finds herself challenged by life to face problems and seek to overcome all evil.

The construction of the character Raquel, in the 2025 version of "Vale Tudo", now as a black woman, accentuates racial issues at an intersectional level, in view of the socioeconomic crossings of the life of this woman who needs to work and fight for the maintenance of family stability, even if the adversities are great. In dialogue with the images of control, Raquel could be the matriarch, or the mother of the black family, represented by the stereotypes of the woman with a suffering life, who needs to fight fervently to move on. Without a husband, without a home of her own, with a daughter who even in adulthood does not work

or study formally, and later without any other parental ties of support, Raquel maintains only her values of honesty and dignity and ode to work and meritocracy as her foundations.

On the other hand, Maria de Fátima is represented as the result of a generation deviated from traditional values, without sentimental attachment, and with the materialistic side developed to the detriment of honesty and valuing work. In addition to not wanting a job in formal standards, seeking apparently simpler solutions, such as a career on the internet, Fátima rescues the stereotype of the self-interested woman, who has no independence and needs to be based on the financial condition of a preferably heteronormative relationship, valuing patriarchy, male domination and the submission of women.

With this, the character is represented in the molds of Jezebel/*hoochie*'s control image, as a young, beautiful woman, who always shows herself attractive, whether by the use of makeup, or clothes that show physical attributes. In addition, Fátima's speeches and attitudes reveal the lack of scruples to achieve what she needs, which may include different strategies, especially sexual involvements as the best, if not the only way to seduce a man from the elite.

In the contrast of the representation of the characters Raquel Acioli and Maria de Fátima, there is, to a certain extent, a dialogue with traditional stereotypes of the construction of an imaginary about black women. Always strong and struggling because of the harshness of life, or driven to lust as a way to conquer what they want, or escape the reality in which they live, Raquel and Fátima, even in a soap opera produced with the intention of being more inclusive and representative of the black audience, represented images of control that still need to be deconstructed.

5 CONCLUSION

When the soap opera addresses a current topic, of interest to the public, or even controversial, it creates a link between fiction and reality, and generates debates in society. Considering that the soap opera can be watched on open TV and *streaming*, and even in excerpts on social networks, there is also an expansion of the reach of this object in terms of audience and forms of discussion. Thus, it is of interest to take the soap opera as an object of study.

When choosing the telenovela "Vale Tudo" for analysis, the relevance of the title to national teledramaturgy was considered, in view of all the social issues discussed, both by the original version, from 1988, and by the 2025 remake. In this sense, thinking about the representation of black women in the plot is of interest to reflect on possible advances or perpetuation of the treatment of the imaginary about this group in society.

Through the discussion, according to Collins (1990), about the images of control (*mammy*, matriarch, mother dependent on the State and Jezebel) about black women, it was possible to understand how stereotypes permeate the relationship that society has with this group. Thus, when choosing the telenovela "Vale Tudo", the relationship of the central characters of the plot, Raquel and Fátima with the images of control, was discussed.

In the verification of how the characters were constructed, analyzing the initial narrative event of the soap opera, from the beginning of the story, to the climax point in which Fátima sells the family house and goes to Rio de Janeiro, there is the contrast created between mother and daughter, as each one develops a typical side of the imaginary about the black woman. While Raquel incorporates traits of the matriarch's image of control, such as the lonely, honest woman who fights for a better life, always believing in work and dignity, Fátima highlights traits of Jezebel/*hoochie*, such as the young and self-interested woman who uses various resources to ascend socially, such as lies and sexuality to achieve what she wants.

In this line, considering that the soap opera has strength as a cultural product that disseminates knowledge, raises debates and can influence the public, causing changes in society, it is urgent to question the representations that are still made of certain social groups and latent issues of today, such as the images of control over black women. Thus, valuing and studying soap operas has all the legitimacy and emergence for the communicational field.

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PRISION MOTHER: THE WORK OF SOCIAL ASSISTENCE AND RIGHTS GUARANTEE

MÃES DO CÁRCERE: A ATUAÇÃO DO ASSISTENTE SOCIAL E A GARANTIA DE DIREITOS

MADRES EN PRISIÓN: EL PAPEL DEL TRABAJADOR SOCIAL Y LA GARANTÍA DE DERECHOS



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ABSTRACT

This article deals with presenting a synthesis of the problematizations of maternal in women's penitentiaries. The research identified the characteristics of women in maternity in the female prison system, as well as analysed the difficulties these women face to get the respect of their human rights. Also coming to investigate how the women's prison system works and the importance of the social worker in the performance and care of the woman in the maternity situation in the female prison system.

Keywords: Women's Prison. Social Services. Mothering. Social Worker. Rights.

RESUMO

Este artigo trata de apresentar uma síntese das problematizações da maternidade nas Penitenciárias Femininas. A pesquisa identificou as características das mulheres em situação de maternidade no sistema carcerário feminino, assim como, analisou as dificuldades que essas mulheres enfrentam para obter o respeito de seus direitos humanos. Vindo também a investigar como funciona o sistema de cárcere feminino e importância do assistente social na atuação e no atendimento da mulher em situação de maternidade no sistema prisional feminino.

Palavras-chave: Cárcere Feminino. Serviço Social. Maternidade. Assistente Social. Direitos.

RESUMEN

Este artículo presenta una síntesis de las problemáticas relacionadas con la maternidad en las cárceles femeninas. La investigación identificó las características de las mujeres que experimentan la maternidad dentro del sistema penitenciario femenino, así como las dificultades que enfrentan para obtener el respeto de sus derechos humanos. También investigó el funcionamiento del sistema penitenciario femenino y la importancia del trabajo social en la atención y el apoyo a las mujeres que experimentan la maternidad dentro de este sistema.

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Palabras clave: Prisión Femenina. Trabajo Social. Maternidad. Trabajador Social. Derechos.

1 INTRODUCTION

The number of women in prison in Brazil is gradually increasing. According to the Ministry of Justice, this increase reached 42% between 2007 and 2012. In five years there was an increase of more than 10,000 (ten thousand) women in the Brazilian prison system

Violations of the rights of incarcerated women and their children have gained space in the growth of the number of inmates in the female prison system. Although the number of incarcerated men is higher, the number of women has grown considerably. However, even with this feminization of prisons, the spaces and policies adopted disregard the feminine particularities. Making it impossible to protect and guarantee their rights and those of their children.

This situation reveals the Brazilian fragility regarding criminal and social policies that concern the reduction of inequalities and the guarantee of citizenship of these women, which has not favored their social reintegration or even their resocialization. This situation of incarceration does not favor the preservation of the health of women and children, causing a true process of exclusion and discrimination with negative repercussions, in the medium and long term, for these women and even for their children.

In this context, this study aims to problematize the constitution of maternity in Women's Penitentiaries and the access of these women to this right. The vast majority of prison institutions are not prepared to meet women's needs. As for maternity in prison, some studies point to the right to breastfeeding in a limited way, without considering the other rights of mother and citizen that the prison has.

In view of the challenges of the work that affect the social assistance professional, the present work also aims to reflect on the performance of the social worker in the female prison system, and also to analyze the possibilities and challenges faced by it, taking into account the prison in its contemporary social function.

For the realization of this article, a literary research was carried out on articles written in Brazil, as well as an analysis of research and data collected in the daily reality of prison women in maternity situations, and also a detailed bibliographic analysis of the main names of Brazilian Social Work.

In the end, it is expected to achieve the objective of analyzing the importance of the social worker in the female penitentiary system in relation to women in maternity situations.

2 FEDERAL LEGISLATION TO GUARANTEE WOMEN PRISONERS

The content collected initially allowed 12 federal norms to be found that guarantee the rights of women in prison in maternity situations and their children.

Table 1

Federal legislation that safeguards the rights of the prison mother and her children

Title	Menu	Articles
<i>Constitution of the Federative Republic of Brazil</i> of 1988		Fundamental rights of female prisoners to an establishment appropriate to their female condition, to breastfeeding their children (Art. 5. XLVIII, L), and to family life (Art. 227).
<i>Decree-Law No. 2,848</i> , of December 7, 1940	Code of Criminal Procedure	Serving the sentence in an establishment appropriate for women (Art. 37).
<i>Decree-Law No. 3,689</i> , of October 3, 1941	Code of Criminal Procedure	Substitution of preventive detention for house arrest (Art. 318).
<i>Law No. 7,210</i> , of July 11, 1984	<i>Penal Execution Law</i>	Medical follow-up of the woman and the newborn (Art. 14. § 3). Mandatory nursery, place for breastfeeding, at least up to 6 (six) months of age (Art. 83. § 2). Mandatory place for pregnant and parturient women, and daycare for children over 6 (six) months and under 7 (seven) years old (Art. 89). Benefit of the open regime in a private residence for convicted women with a minor or physically or mentally disabled child; convicted pregnant woman (Art. 117).
<i>Law No. 10,406</i> , of January 10, 2002	Civil Code	Possibilities of suspension of family power to a father or mother convicted by an unappealable sentence, due to a crime whose penalty exceeds two years in prison (Art. 1.583, § 5; art. 1.637 and 1.638).
<i>Law No. 8,069</i> , of July 13, 1990	<i>Statute of the Child and Adolescent</i>	Adequate conditions for breastfeeding and living with the imprisoned mother (Art. 9). Dignified conditions and full protection of the child (Art. 3, 4, 5 and 7). Freedom and coexistence of the child with the mother (Art. 16 and 19). Family power and criminal conviction (Art. 23). Hearing of parents in adoption and child custody proceedings (Art. 158).
<i>CNPCP Resolution No. 14</i> , of November 11, 1994	Minimum Rules for the Treatment of Prisoners.	Conditions for the permanence of children with prisoners during the breastfeeding period (Art.7, §§ 1 and 2). Provision of obstetric material in the prison establishment in case of emergency (Art.17).
<i>CNPCP Resolution No. 04</i> , of July 15, 2009	Regulates the permanence of the children of prisoners in prison environments.	Guidelines for the permanence and referral of the children of prisoners (Art.2). Permanence of at least one year and six months with incarcerated mothers (Art.1). Gradual process of separation (Art.3). Possibilities for sheltering children: extended family, surrogate family or institutions (Art.4). Nursery for children up to two years old (Art.6) Possibility of children from two to seven years old staying with their mothers in the prison unit (Art.7). Food (Art.5). Visits by imprisoned family members and parents (Art.9). Leave of absence from work activity (Art.10). Responsibility of the Union and the States to build and maintain women's penitentiaries with a nursery (Art.8). Possibility of changing the terms and conditions of permanence of children in the prison unit (Art.12).
<i>CNPCP Resolution No. 09</i> , of	Basic Guidelines for Penal Architecture.	Section for pregnant and parturients; daycare centers - nursery module (Annex V).

November 18, 2011		
<i>CNPCP Resolution No. 3, of June 1, 2012</i>	Recommendation on the use of handcuffs.	The use of handcuffs or other means of restraint during childbirth and during the subsequent rest period is prohibited (Art. 3). Recommendation to health professionals to formally report misuse (Art. 5).
<i>Ordinance MS/MJ No. 1,777, of September 9, 2003</i>	National Health Plan in the Penitentiary System.	Women's health. Prenatal, childbirth and postpartum care in 100% of penitentiary units. There is no reference to a pediatrician, or monitoring of the children
National Plan for Criminal and Penitentiary Policy	National Plan for Criminal and Penitentiary Policy - CNPCP/MJ 26/04/2011.	Prenatal care and the existence of specific spaces and services for pregnant women during pregnancy and during the period of their children's stay in the prison environment.

Source: Authors.

There is a disparity between the legislations, and this heterogeneity and the lack of norms to regulate the situation of the child with the mother aggravates the discretionary character sent to the management of penal establishments

The absence of legislative content on the subject indicates aspects that are harmful to the protection of rights that affect their health. The lack of interest in legislating such a controversial issue shows the social, legal and administrative invisibility of children living with their mothers in prisons.

3 CRESS/CFESS GUIDELINES

Social workers, as active professionals and defenders of human rights, must be guided by the careful observance of the competence guidelines established by the CRESS/CFESS, as well as by the Code of Ethics of the profession.

Professional intervention in Social Assistance policy cannot have as its horizon only the execution of the activities listed in institutional documents, at the risk of limiting its activities to the "management of poverty" from the perspective of the individualization of social situations and of approaching the social issue from a moralizing bias. (CFESS, 2009, p.5).

Table 2

General and specific competencies of the social work professional according to CFESS guidelines

GENERAL COMPETENCIES OF THE SOCIAL WORKER	SPECIFIC COMPETENCIES OF THE SOCIAL WORKER
Critical apprehension of the social processes of production and	A dimension that encompasses individual, family or group approaches from the perspective of meeting basic needs and access to rights,

reproduction of social relations in a perspective of totality;	goods and public equipment. This dimension should not be guided by psychotherapeutic care for individuals and families (proper to Psychology), but rather to the enhancement of social orientation with a view to expanding the access of individuals and the community to social rights;
Analysis of the historical movement of Brazilian society, apprehending the particularities of the development of Capitalism in the country and the regional particularities;	A dimension of collective intervention with social movements, from the perspective of the socialization of information, mobilization and popular organization, which is based on the recognition and strengthening of the working class as a collective subject in the struggle for the expansion of rights and state accountability;
Understanding of the social meaning of the profession and its socio-historical development, in the international and national scenarios, unveiling the possibilities of action contained in reality;	A dimension of professional intervention aimed at insertion in democratic spaces of social control and construction of strategies to foster the participation, claim and defense of rights by users and Councils, Conferences and Forums of Social Assistance and other public policies;
Identification of the demands present in society, aiming to formulate professional responses to face the social issue, considering the new articulations between the public and the private.	A dimension of management, planning and direct execution of goods and services to individuals, families, groups and collectivity, in the perspective of strengthening democratic and participatory management capable of producing, intersectorally and interdisciplinarily, proposals that enable and enhance management in favor of citizens;
	A dimension that materializes in the systematic realization of studies and research that reveal the real living conditions and demands of the working class, and can feed the process of formulation, implementation and monitoring of the Social Assistance policy;
	A pedagogical-interpretative and socializing dimension of information and knowledge in the field of rights, social legislation and public policies, aimed at the various actors and subjects of politics: public managers, directors of service providers, workers, counselors and users.

Source: Authors.

The documentary content analyzed, allowed the analysis of the professional profile of the social worker in the performance of the guarantee of the fulfillment of the rights of prison women in maternity situations and their children, this being observed by the social assistance professional the Parameters of their competence according to the CFESS/CRESS.

Professional action is restricted because of the system that is included and also all the bureaucracy that this system presents. Social work as a profession acts in the expressions of social issues and social relations and aims at the struggle for human rights in Brazil, the realization of these rights and also the denunciation of the non-fulfillment of the rights of convicts in prison units.

4 SOCIAL VISION OF FEMALE CRIMINALITY

With the observation of the female prison reality and the profile of the prison woman, the multiple faces of social marginalization that marks the trajectory of most imprisoned women are revealed. They are marked both by socioeconomic exclusion, gender and race discrimination, as well as by a history of violence and drug abuse.

Different economic and sociocultural studies are unanimous in stating that the majority of women prisoners are young, aged between 20 and 35 years, belong to ethnic minority groups, poor, single mothers, with low education, without professional qualifications, unemployed or employed in a low-skilled position and with low income.

In addition to these profiles, the survey also revealed that women prisoners have a history of violence in childhood and adolescence, including physical assault, rape, alcohol and drug abuse.

However, these problems pointed out originated from historical and social facts that began centuries ago. As Cláudia Gabriele da Silva argues:

It is from the second half of the eighteenth century, with the advent of the Industrial Revolution, that the prison system began to be modeled according to the interests of the capitalist class, where the inmates served as labor to circumvent idleness, through coercive methods. Over time, the penalties were adapted to the crimes, becoming more "humanized" and this work developed in the capitalist spheres of production began to serve for the custody of the convict. However, the character of punishment, coercion and modeling of "being" according to the norms of the functional capitalist society did not cease to exist. (Silva, Cláudia Gabriele da, 2007, p. 3)

The capitalist economic and political model, through a meritocratic ideology, annuls the differences, subjectivities and distinct opportunities of the beings who live in its context, introducing personal will as the only condition for success, limited to the economic, in which "we are what we have".

For Iamamoto:

It is in the context of world globalization under the hegemony of big financial capital, of the alliance between banking capital and industrial capital, that we witness the technical-scientific revolution based on microelectronics, establishing new patterns of producing and managing work. At the same time, the demand for labor is reduced, the surplus population is expanded to the average needs of capital itself, increasing the social, economic, political, and cultural exclusion of men, young people, children, and women from the subaltern classes, who are now the target of institutionalized violence. This social exclusion becomes, contradictorily, the product of the development of collective work. In other words, pauperization and exclusion are the other face of the development of the productive forces of social labor, the development of science and technology, the

means of communication, production, and the globalized market. (IAMAMOTO, Marilda, 2000, p. 14)

In recent years, the portrait of social exclusion that women were subjected to before prison has deepened even more with incarceration. The hypothesis that there is a relationship of continuity, between participation in criminal activities and the experiences of abusive relationships, or immersion in violent environments, lived in childhood, adolescence and/or adulthood, the current discrimination and deep inequality caused for years by a perverse capitalist system that corrupts society and the political system, It seems that they only contribute to the increase and narrowing of relations between crime and marginality with women.

5 SCENARIO OF WOMEN'S PROFESSIONAL INSTITUTIONS

The situation of national prisons is of great concern. The overcrowding and precariousness of these institutions are largely caused by omissions by the Public Power, thus generating an alarming picture of violations of the human rights of the incarcerated.

In this scenario of bankruptcy of the prison system, women suffer more rights violations, considering that they are in a system designed by men and structured by men, resulting in a model that does not pay attention to the needs and peculiarities of women, among them the maternity of incarcerated women, the main theme of this work.

Motherhood brings with it both physiological and social responsibility. And these were imposed on women, and they were accompanied by this imposition also in the prison environment.

The Federal Constitution of 1988 guarantees the right to health and social assistance, and these rights must also be observed in relation to incarcerated women, especially if they are in a situation of maternity.

It is the responsibility of the State to guarantee social support, and also the essential for nutrition, hygiene and health of mother and child, especially if they are in a situation of incarceration.

This opens a reflection on the existence and application of human rights and the difficulties that the social worker faces in the performance of the profession where there is a lack of resources, both material and physical and human

As a result, the woman in a situation of maternity faces several difficulties, and there is no human dignity for both, where the first six months of life are the most important for the human being.

The social worker has been fighting to guarantee the rights of all and the realization of them.

6 CONCLUSIONS

We live in a social moment with growing crime, and based on the premise that the national prison system is precarious and presents itself as a violator of human rights, disrespecting the guarantees provided to prisoners and mainly hurting one of the main foundations of the Democratic Rule of Law: human dignity.

It was identified that, despite initiatives that show concern for women prisoners, the laws that guarantee humane treatment to prison mothers and that aim to enable the continuity of motherhood in prison, in practice, are not effective.

Therefore, one of the current challenges of the social worker profession is to make the professional practice effective within women's prison institutions, effectively materializing the fulfillment of human rights standards and fundamental guarantees of the prison mother and her child, in an attempt to overcome a system of social and punitive control. The work of the social worker in the Brazilian prison system is surrounded by many limitations, conflicts and difficulties.

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LOVE, SURVEILLANCE AND VIOLENCE IN RAFIKI (2018): A LESBIAN FEMINIST READING

AMOR, VIGILÂNCIA E VIOLÊNCIA EM RAFIKI (2018): UMA LEITURA FEMINISTA LÉSBICA

AMOR, VIGILANCIA Y VIOLENCIA EN RAFIKI (2018): UNA LECTURA FEMINISTA LÉSBICA



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ABSTRACT

This article examines how *Rafiki* (2018) articulates love, surveillance and violence in its representation of lesbian experience. Drawing on a lesbian feminist reading of Wanuri Kahiu's film, inspired by Monica Arac de Nyeko's short story "Jambula Tree," the study argues that the film constructs the bond between Kena and Ziki as a force of mutual recognition while exposing the familial, social, and institutional mechanisms mobilized to discipline dissident desire. Methodologically, the discussion focuses on two sequences, read through the concepts of compulsory heterosexuality, heteronormativity, intersectionality, and lesbophobia in dialogue with formal elements of film language such as framing, lighting, color, and point of view. The analysis shows that *Rafiki* juxtaposes scenes of reciprocity, chromatic warmth, and affective openness with scenes of public exposure, humiliation, and coercion, thereby revealing that violence against lesbian women operates in both physical and symbolic registers. The article concludes that the film performs an aesthetically and politically significant intervention by affirming the legitimacy of desire between women and by making visible the social costs imposed on its existence.

Keywords: Film Analysis. Lesbian Existence. Heteronormativity. Love. Violence.

RESUMO

Este artigo examina como *Rafiki* (2018) articula amor, vigilância e violência em sua representação da experiência lésbica. Com base em uma leitura feminista lésbica do filme de Wanuri Kahiu, inspirado no conto "Jambula Tree", de Monica Arac de Nyeko, o estudo sustenta que o filme constrói o vínculo entre Kena e Ziki como uma força de reconhecimento mútuo, ao mesmo tempo em que expõe os mecanismos familiares, sociais e institucionais mobilizados para disciplinar o desejo dissidente. Metodologicamente, a discussão concentra-se em duas sequências, lidas à luz dos conceitos de heterossexualidade compulsória, heteronormatividade, interseccionalidade e lesbofobia, em diálogo com elementos formais

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da linguagem cinematográfica, como enquadramento, iluminação, cor e ponto de vista. A análise mostra que Rafiki justapõe cenas de reciprocidade, calor cromático e abertura afetiva a cenas de exposição pública, humilhação e coerção, revelando, assim, que a violência contra mulheres lésbicas opera tanto em registros físicos quanto simbólicos. O artigo conclui que o filme realiza uma intervenção estética e politicamente significativa ao afirmar a legitimidade do desejo entre mulheres e ao tornar visíveis os custos sociais impostos à sua existência.

Palavras-chave: Análise Fílmica. Existência Lésbica. Heteronormatividade. Amor. Violência.

RESUMEN

Este artículo examina cómo Rafiki (2018) articula el amor, la vigilancia y la violencia en su representación de la experiencia lésbica. A partir de una lectura feminista lésbica de la película de Wanuri Kahiu, inspirada en el cuento “Jambula Tree” de Monica Arac de Nyeko, el estudio sostiene que la película construye el vínculo entre Kena y Ziki como una fuerza de reconocimiento mutuo, al tiempo que expone los mecanismos familiares, sociales e institucionales movilizadas para disciplinar el deseo disidente. Metodológicamente, la discusión se centra en dos secuencias, leídas a través de los conceptos de heterosexualidad obligatoria, heteronormatividad, interseccionalidad y lesbofobia, en diálogo con elementos formales del lenguaje cinematográfico, como el encuadre, la iluminación, el color y el punto de vista. El análisis muestra que Rafiki yuxtapone escenas de reciprocidad, calidez cromática y apertura afectiva con escenas de exposición pública, humillación y coerción, revelando así que la violencia contra las mujeres lesbianas opera tanto en registros físicos como simbólicos. El artículo concluye que la película lleva a cabo una intervención estética y políticamente significativa al afirmar la legitimidad del deseo entre mujeres y al visibilizar los costos sociales impuestos a su existencia.

Palabras clave: Análisis Fílmico. Existencia Lésbica. Heteronormatividad. Amor. Violencia.

1 INTRODUCTION

The portrayal of lesbian desire has been in a somewhat marginal position within the landscape of mainstream cinema. For decades, women in cinema have been presented largely as objects of male desire, while same-sex relationships, when represented at all, have tended to privilege male experience or to limit female homoeroticism to fetishized spectacle. Within this context, lesbian subjectivities are pertinent here not simply because the film makes spaces of recognition, visibility, and contestation. They do not merely increase the variety of media representations, they challenge the cultural norms of what desires could be publicly accepted as legitimate.

Rafiki (2018), directed by Wanuri Kahiu and inspired by Monica Arac de Nyeko's award-winning short story "Jambula Tree," is meaningful for that dispute being staged. Set in Nairobi, the film examines two love-struck young women, Kena and Ziki, in a conservative society governed by political competition, familial pressures and public hostility. Not one of the narratives treats their relationship as a private, out-of-touch piece cut off from the rest the society. On the contrary, the film shows how the coming to intimacy of the protagonists is immediately mediated by gender norms, community surveillance, and the threat of punishment.

The relevance of the film is amplified by its circulation history. Rafiki was the first Kenyan feature selected for the Cannes Film Festival's official lineup, yet it was banned in Kenya because of its portrayal of a lesbian relationship. This contrast between international recognition and domestic censorship reveals how representation becomes a political battlefield. The reception of the film reflects one of its central concerns: the conflict between the possibility of queer visibility and the mechanisms that attempt to suppress it.

This article argues that Rafiki establishes love and violence as inseparable facets of lesbian experience within a heteronormative social order, with surveillance as the conduit that units them. Love is not presented as an exclusive private emotion, nor is violence limited to explicit physical aggression. Rather, the film posits that tenderness, desire, fear, secrecy, humiliation, and punishment are intricately linked in contexts where heterosexuality is perceived as mandatory standard. The objective of this study is to examine how the film portrays both the emotional intensity of the protagonists' relationship and the violent responses elicited by that relationship.

For that reason, the discussion focuses on two sequences. The first, which takes place between 19m18s and 21m45s, is examined as an important moment in building closeness and mutual recognition. The second, from 53m50s and 1h00m30s, is looked at as a focused example of violence in public and institutions. By placing these scenes in dialogue with lesbian

and feminist theory as well as with selected elements of film language, this article aims to show that *Rafiki* transcends the mere narration of a forbidden romance: it reveals the societal repercussions faced by lesbian individuals while affirming their emotional authenticity and cinematic significance.

2 THEORETICAL FRAMEWORK

Adrienne Rich's (1980) concept of "compulsory heterosexuality" is a good place to start when reading *Rafiki*. Rich argues that heterosexuality should not be understood simply as a personal inclination or natural destiny, but as a political institution that secures male power and structures women's lives according to gendered norms of marriage, procreation, and servitude. Within this context, lesbian existence is threatening not only because it deviates from sexual normativity, but also because it exposes the non-inevitability and non-neutrality of heterosexuality. It is created by history, enforced by society, and supported by material things.

This debate is closely linked to the concept of heteronormativity. Cathy Cohen (2019) says that heteronormativity includes social practices and institutions that make heterosexuality the "normal" and "expected" way to live your intimate life. It controls not just desire but also behavior, appearance, family ties, and how people see you in public. In this regard, the issue extends beyond the object of affection, it encompasses the manner of occupying public space, the performance of femininity, and the interpretation of bodies by others. *Rafiki* dramatizes these pressures by situating Kena and Ziki in a place where family, neighbors, and state all have a say in how close they can get to each other.

Lesbian feminist scholarship has demonstrated that violence against lesbians cannot be entirely encompassed by the broader category of homophobia. The concept of lesbophobia underscores the particularity of violence inflicted upon women whose desires subvert both heterosexuality norms and conventional femininity. Rojas and Mansilla (2021) assert that this violence often seeks to discipline women regarded as rejecting the heterosexual contract. It can be physical, verbal, sexual, or symbolic, but in all cases, it works to bring the norm back by making lesbian desire seem strange, wrong or punishable.

The concept of abjection also helps us understand the social logic behind these reactions. When certain bodies or desires are deemed unacceptable, they become linked with disgust, shame, or moral danger. Silence, ridicule, erasure, and exclusion are not secondary phenomena; they are essential to the construction of social order. Navarro-Swain (2000) asserts that the politics of silence is intricately connected to the politics of forgetting; that which threatens prevailing values is often obliterated, disqualified, or denied discursive validity. This

logic is evident in *Rafiki* through everyday interactions and in more explicit instances of collective aggression.

It is also crucial to refrain from perceiving lesbian experience as socially uniform. Crenshaw (2002) defines intersectionality as the study of how different systems of oppression work together instead of separately. Gender, sexuality, race, class, age, and nationality intersect to influence vulnerability. This perspective is particularly relevant to *Rafiki*, as the protagonists are not merely abstract lesbians; they are young Black Kenyan women living in a working-class urban setting. That social location shapes how they feel about being seen, being in danger, and wanting something. Lorde (2019) reminds us that the systems of oppression stay in place when people refuse to see and value differences. An intersectional reading, therefore, inhibits the analysis from reducing the film into a universal narrative divorced from its particular historical and cultural context.

Film analysis also requires attention to form. Meaning in cinema does not just come from the plot or the dialogue. It also comes from the framing, lighting, costume, sound, rhythm, and camera movement. Turner (1999) proposes that images gain social significance through these specific formal choices. Camera angles can set up power dynamics, color can suggest mood, and point-of-view structures can help audience connect with the story. In *Rafiki*, the difference between scenes of violence and scenes of intimacy is made clear both in the story and in the pictures. Surveillance, distance, and coldness coexist with warmth and color. The film's political power comes from the way it connects representation and form: it shows lesbian desire while also showing the system that tries to control it.

3 METHODOLOGICAL NOTE

This is a qualitative and interpretive study based on film analysis and lesbian feminist criticism. Instead of trying to read the whole feature, the article focuses on two sequences that sum up the main conflicts of the story. This method enables the connection of formal choices overarching issues of representation, normativity, and violence.

The analysis integrates two dimensions. The first is theoretical one that mostly uses Rich's (1980) notion of compulsory heterosexuality, talks about heteronormativity and lesbophobia, and looks at the intersectional perspectives that make it hard to read lesbian experience in a universal way. The second is formal, focusing on *mise-en-scène*, framing, costume, lighting, point of view, and editing. These elements are important to how the film makes sense. The goal of the analysis is to understand how the language of the film itself helps create closeness, surveillance, and punishment.

4 ANALYSIS AND DISCUSSION

4.1 LOVE, RECOGNITION, AND THE POSSIBILITY OF A SHARED WORLD

The part of the film between 19m18s and 21m45s is important because it presents intimacy not as a spectacle, but as a relationship. Kena and Ziki sit together on a balcony and exchange a brief but significant conversation about not becoming like “them” and about being “something real.” There are no excessive statements or sexual excess in the scene. Instead, it shows love as a fragile but transformative space where each girl can see herself and the other girls in a new way.

The scene’s visual design is decisive. At first, both characters look happy in a frontal shot that puts them in the same frame. After a short time, the editing gives each girl a chance to show how she sees the other by switching between shots. This strategy creates closeness by making people see Kena through Ziki’s eyes and Ziki through Kena’s. The effect is not voyeurism, but mutualism. The scene encourages identification with the act of careful observation instead of an external gaze that objectifies the girls.

The difference is made clearer by the lighting. Ziki is often surrounded by warm light, which can make her look almost overexposed. That gives her presence a bright and expansive quality. Kena, on the other hand, is framed with stronger contrast and a softer tone. The difference does not show a simple opposition between darkness and light; instead, it shows how important Ziki becomes in Kena’s life. If Kena’s social world has put her in a place of restraint, silence, and caution, Ziki seems to be a person of movement, color, and possibility. The costumes also add to the contrast: Kena’s more neutral clothes suggest discretion, while Ziki’s bright colors and bold styling suggest openness and confidence in performance.

These formal choices are crucial because they go against a long-standing trend in films where women are shown being close to each other through heterosexual fantasy. The scene does not fetishize lesbian desire. It puts conversation, facial expressions, pauses, and emotional alignment first. The movie shows that love is growing through friendship, curiosity, and recognition even before the main characters kiss. In this way, *Rafiki* broadens the idea of eroticism beyond just sexual acts. Rich (1980) helps here because her writing shows that the erotic can be seen as a way of relating, being intense and sharing life force, rather than just as a sexual pornographic register.

The scene also gains meaning because of where it fits into film’s larger social landscape. Before Ziki showed up, Kena was always surrounded by comments and attitudes that make non-normative sexuality seem strange or funny. Given this, the conversation on the balcony is a brief break from public hostility. It creates a space where the audience can picture a different

way of living in the world, even if it is for a short time. In this sequence, love is not merely emotional attachment; it signifies the emergence of a possible shared reality.

At the same time, the scene is both tender and fragile. The girls' pact "to be something real" already shows that they know that reality is something that people disagree about. Their connection is meaningful because the world around them tries to make it seem unreal, unspeakable, or illegitimate. The scene foreshadows the film's main point: in a under heteronormative world, closeness between women is politically charged not because it seeks confrontation, but because it challenges the idea that heterosexuality is normal and shows how it is enforced.

4.2 VIOLENCE, EXPOSURE, AND THE ENFORCEMENT OF THE NORM

The first sequence is based on reciprocity, while the one between 53m50s and 1h00m30s is based on exposure. Ziki's mother first sees the girls kissing. Then they ran to the van that had been their safe haven throughout the film. Finally, they are found, beaten, and taken to a police station. The scene focuses on different levels of coercion and shows how violence spreads through private, public, and institutional spaces when intimacy becomes something that everyone watches.

One of the most striking aspects of the sequence is the breakdown of personal safety. The van had been a liminal space before, where the main characters could briefly escape surveillance. Once that safe space is breached, violence escalates rapidly. Mama Atim's public condemnation turns the girls from victims into a spectacle of community anger. The words used to call others make them seem dirty and disgusting, setting the stage for physical violence. What follows is not just one act of cruelty, but a group effort to enforce the norm. The mob thinks that punishing visibility is a way of bring back moral order.

In this case, lesbophobia seems to be more than just personal bias; it also seems to be a form of social education. The beating is meant to punish, shame, and "fix" the girls by making their bodies pay for being seen. The violence is public, gendered, and exemplary: it shows the rest of the community what could happen to people who do not follow the heterosexual mandate. The scene thus confirms that coercion does not initiate with physical assault; rather it culminates there, after having been facilitated by gossip, derision, moral condemnation, and surveillance.

Instead of stopping this line of thought, the police station makes it stronger. Institutional authority which should signify the shift from violence to protection, instead perpetuates the same contempt that characterized the assault. The officers' mockery – particularly the inquiry

regarding the identity of “the man” in the relationship - exposes the inadequacy of heteronormative discourse to understand lesbian intimacy beyond masculine-feminine dichotomies. The question is not innocent; it forces the relationship back into the grammar of heterosexual roles and thereby denies its own terms of existence.

Family reactions make the situation even more difficult. Ziki’s father responds with a slap, while Kena’s father tries to manage the situation by talking to the police chief. These gestures may look different, but they both come from patriarchal control. Ziki’s mother’s comment, “Haven’t you hurt her enough?” is especially revealing because it draws attention to how often victims are blamed for the violence that is done to them. People do not think of the girls as people who need care; instead, they think of them as the people who cause trouble in the community.

The sequence shows rupture and desolation in a cinematic way. The police station scene is colder, with harsher light and a more static frontal framing than the earlier balcony scene, which was warmer. The camera often makes the girls look small and weak in a setting that does not feel personal. The distance between them in a frame shows how the attack affected them emotionally. The film shows how trauma can have different but connected effects: one person reaches out, while the other pulls back to protect themselves. This is shown when Kena looks at Ziki while Ziki looks away.

The change in point of view is also significant. Earlier, the alternating shots had helped the main characters get along with each other. Here, frontal compositions and the lack of a long-lasting mutual perspective create estrangement. The viewer is no longer part of the intimate exchange of gazes; instead, they see the aftermath of violence and the girls being forced to be apart. The change in form makes the broader thematic movement from possibility to punishment stand out even more.

Yet the scene should not be about being a victim. Its strength lies in showing how heteronormative society protects itself. Public assault, institutional derision, and familial discipline collectively serve to regulate women’s bodies and desires. In this regard, the violence portrayed in *Rafiki* is not exceptional; it is systemic. The film shows how everyday people, rumors in the community, police talk, and parental authority all help to keep norms going. Love becomes dangerous not due to its intrinsic transgressiveness, but because the social order is committed to denying the humanity of lesbian and normalizing surveillance as a standard mechanism of control.

5 FINAL CONSIDERATIONS

Rafiki portrays love and violence not as opposing and isolated forces, but as experiences that intertwine within heteronormative contexts. The relationship between Kena and Ziki is characterized by tenderness, reciprocity, and emotional depth, however, it is precisely these attributes that render the relationship vulnerable to surveillance and punishment. The film's success is that it does not turn lesbian desire into either a spectacle or a disease. Instead, it shows lesbian intimacy as normal, important and very human.

The analysis of the two chosen sequences illustrates that the film articulates this argument both narratively and structurally. Rafiki uses color, framing, lighting, and point of view to show the difference between spaces of emotional possibility and spaces of coercion. Moments of warmth and recognition are juxtaposed with communal animosity, public scrutiny, and institutional degradation. The film shows that violence against lesbian women is not just physical; it is also supported by symbolic, discursive, and social practices that try to make their existence seem illegitimate.

From a lesbian feminist point of view, the film is politically important because it shows how personal relationships are connected to larger systems of power. Kena and Ziki's story is not just about desire; it is also about who can show up, love, and picture a future. Rafiki challenges the normalization of compulsory heterosexuality and expands the scope of cinematic representation by affirming the protagonists' emotional bond in the face of censorship and hostility. So, its intervention is both aesthetic and political; it says that lesbian lives should not be shown on screen as cautionary tales, but as lives that deserve complexity, dignity, and visibility.

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DEVELOPMENT AND APPLICATION OF AN ANATOMICAL BIOMODEL FOR TEACHING ORCHIECTOMY IN DOGS

DESENVOLVIMENTO E APLICAÇÃO DE BIOMODELO ANATÔMICO PARA O ENSINO DA ORQUIECTOMIA EM CÃES

DESARROLLO Y APLICACIÓN DE UN BIOMODELO ANATÓMICO PARA LA ENSEÑANZA DE LA ORQUIECTOMÍA EN PERROS



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ABSTRACT

The teaching of veterinary surgery requires strategies that enable the development of technical skills in a safe and ethical manner. In this context, the present study aimed to develop an anatomical biomodel of the male canine genitourinary region for training in the orchiectomy technique, as well as to evaluate its applicability as a didactic tool. The biomodel was constructed using low-cost materials, including biscuit modeling clay for support structures, clear rubber for internal anatomical components, and platinum-cured transparent silicone to simulate the skin layer. After fabrication, the model was subjected to practical testing, in which the fundamental steps of the surgical procedure, such as incision, dissection, and manipulation of anatomical structures, were performed. The results demonstrated that the biomodel presented adequate anatomical fidelity and mechanical properties compatible with surgical simulation, allowing the procedure to be carried out in a safe and reproducible manner. From an educational perspective, the model enabled repeated practice in a controlled environment, contributing to the improvement of practical skills, reduction of errors, and increased student confidence. Furthermore, its use is aligned with the principles of reduction, refinement, and replacement (3Rs), representing an ethical alternative to the use of animals in teaching. It is concluded that the proposed biomodel has strong potential to be incorporated as a complementary tool in veterinary surgical education, contributing to the training of more qualified professionals.

Keywords: Anatomical Biomodels. Orchiectomy. Surgical Training. Teaching Innovation. Veterinary Education.

RESUMO

O ensino da cirurgia veterinária exige estratégias que possibilitem o desenvolvimento de habilidades técnicas de forma segura e ética. Nesse contexto, o presente estudo teve como

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objetivo desenvolver um biomodelo anatômico da região geniturinária de cães machos para o treinamento da técnica de orquiectomia, bem como avaliar sua aplicabilidade como ferramenta didática. O biomodelo foi confeccionado com materiais de baixo custo, incluindo massa de biscoito para estruturas de sustentação, clear rubber para as estruturas internas e silicone transparente à base de platina para simulação da pele. Após a confecção, o modelo foi submetido a testes práticos, nos quais foram realizadas as etapas fundamentais do procedimento cirúrgico, como incisão, dissecação e manipulação das estruturas anatômicas. Os resultados demonstraram que o biomodelo apresentou adequada fidelidade anatômica e propriedades mecânicas compatíveis com a simulação cirúrgica, permitindo a execução do procedimento de forma segura e reprodutível. Do ponto de vista educacional, o modelo possibilitou a repetição das técnicas em ambiente controlado, contribuindo para o aprimoramento das habilidades práticas, redução de erros e aumento da confiança dos estudantes. Além disso, sua utilização está alinhada aos princípios dos 3Rs, configurando-se como alternativa ética ao uso de animais no ensino. Conclui-se que o biomodelo proposto apresenta potencial para ser incorporado como ferramenta complementar no ensino da cirurgia veterinária, contribuindo para a formação de profissionais mais qualificados.

Palavras-chave: Biomodelos Anatômicos. Ensino Veterinário. Inovação Didática. Orquiectomia. Treinamento Cirúrgico.

RESUMEN

La enseñanza de la cirugía veterinaria requiere estrategias que permitan el desarrollo de habilidades técnicas de forma segura y ética. En este contexto, el presente estudio tuvo como objetivo desarrollar un biomodelo anatómico de la región genitourinaria de perros machos para el entrenamiento en la técnica de orquiectomía, así como evaluar su aplicabilidad como herramienta didáctica. El biomodelo se elaboró con materiales de bajo costo, incluyendo masa para galletas para las estructuras de soporte, caucho transparente para las estructuras internas y silicona transparente a base de platino para la simulación de la piel. Tras su construcción, el modelo se sometió a pruebas prácticas, en las que se realizaron los pasos fundamentales del procedimiento quirúrgico, como la incisión, la disección y la manipulación de las estructuras anatómicas. Los resultados demostraron que el biomodelo presentaba una fidelidad anatómica adecuada y propiedades mecánicas compatibles con la simulación quirúrgica, lo que permitió realizar el procedimiento de forma segura y reproducible. Desde un punto de vista educativo, el modelo permitió la repetición de técnicas en un entorno controlado, contribuyendo a la mejora de las habilidades prácticas, la reducción de errores y el aumento de la confianza del alumnado. Además, su uso se alinea con los principios de las 3R, consolidándose como una alternativa ética al uso de animales en la enseñanza. Se concluye que el biomodelo propuesto tiene el potencial de incorporarse como una herramienta complementaria en la formación en cirugía veterinaria, contribuyendo a la capacitación de profesionales más cualificados.

Palabras clave: Biomodelos Anatómicos. Enseñanza Veterinaria. Innovación Didáctica. Orquiectomía. Entrenamiento Quirúrgico.

1 INTRODUCTION

Veterinary Medicine plays an essential role in promoting animal health and welfare, requiring professionals to possess a solid technical background combined with a thorough understanding of the anatomical, physiological, and surgical characteristics of different species. In this context, the teaching of anatomy and surgical techniques represents one of the fundamental pillars of academic training, providing the basis for the development of clinical and operative competencies (Dyce; Sack; Wensing, 2019; Köning; Liebich, 2021).

Traditionally, veterinary anatomy teaching has been based on the use of cadavers and anatomical specimens, allowing direct contact with real structures and enhancing the three-dimensional perception of the organism. However, the acquisition, preservation, and maintenance of these materials present limitations related to specimen availability, operational costs, and sanitary requirements. In addition, preservation methods may alter tissue properties and compromise anatomical fidelity (Carvalho et al., 2013; Evans; De Lahunta, 2018).

At the same time, there is a growing concern regarding the ethical aspects associated with the use of animals for educational purposes. In this scenario, the principles of the 3Rs—reduction, refinement, and replacement—stand out, guiding the development of more ethical and sustainable alternative methodologies (Russell; Burch, 1959; Oliveira; Notomi, 2023; Knight, 2011).

In response to these demands, the incorporation of innovative educational technologies has gained prominence in veterinary education. Among these, the use of artificial anatomical models emerges as a relevant complementary strategy, allowing the reproduction of biological structures through synthetic materials and enabling their repeated use in practical activities. Studies indicate that three-dimensional models contribute to the spatial understanding of anatomical structures and support active learning methodologies (Barros; Schmidt, 2019; Ayres et al., 2020; McGaghie et al., 2010).

Anatomical biomodel can be produced using different materials, such as silicone, resins, and low-cost synthetic compounds, making their application feasible across diverse institutional settings. Their ability to faithfully reproduce organs and anatomical systems enables the development of accessible and adaptable teaching resources. Evidence demonstrates that the use of these models enhances practical learning and contributes to the consolidation of anatomical knowledge (Macedo et al., 2021; Nascimento; Silva, 2021; Santos et al., 2021; Botti et al., 2018).

Beyond anatomical teaching, artificial models have been widely used for the training of surgical skills. Procedures such as orchiectomy in dogs are routine in small animal practice and

require technical proficiency and surgical confidence. In this context, prior training in simulated environments allows the development of motor skills, familiarization with procedural steps, and reduction of errors in clinical practice (Slatter, 2020; Toniollo; Vicente, 2017; Seymour et al., 2002).

Studies indicate that the use of anatomical biomodels in surgical training improves technical performance, increases procedural safety, and reduces the occurrence of errors in real interventions. Furthermore, it enables repeated practice and promotes learner autonomy (Silva; Lopes, 2018; Ziegler; Souza, 2021; Issenberg et al., 2005).

Thus, the use of biomodels represents a viable educational tool aligned with contemporary demands in veterinary training, contributing to pedagogical innovation, adherence to ethical principles, and the improvement of practical skills.

In light of the above, the present study aimed to develop an anatomical biomodel of the male canine genitourinary region for training in the orchiectomy technique, as well as to evaluate its applicability as a didactic tool in veterinary surgical education. Additionally, it sought to contribute to the preparation of students prior to performing procedures on real patients, promoting greater safety and reducing errors during the procedure.

2 METHODOLOGY

2.1 STUDY DESIGN

This study was designed as an experimental investigation focused on the development of an anatomical biomodel of the male canine reproductive system, with a didactic and educational purpose. The primary aim was to produce a safe, reproducible, and low-cost anatomical model that could be applied in practical teaching activities for veterinary students, minimizing exposure to hazardous chemicals and enhancing both spatial and tactile understanding of complex anatomical systems.

2.2 MATERIALS

Low-cost and easily accessible materials were used, including biscuit modeling clay for structural modeling, clear rubber for the fabrication of internal anatomical structures, and platinum-cured transparent silicone for simulating the skin layer.

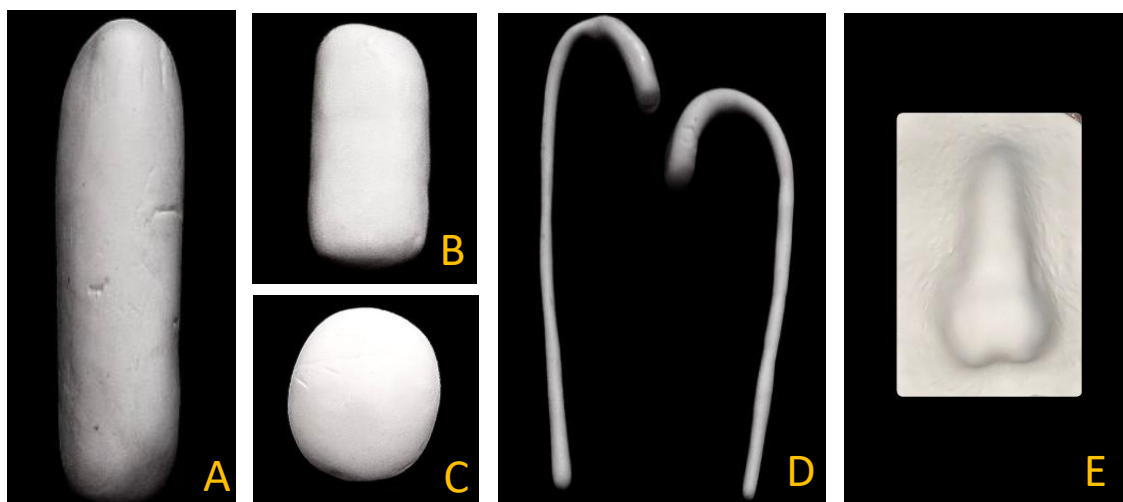
Auxiliary materials included silicone adhesive, wool string, and plastic containers. Personal protective equipment (gloves and lab coat) was used throughout the fabrication process, which was conducted in a controlled environment without direct light exposure or external disturbances to ensure material stability and consistency.

2.3 FABRICATION OF BISCUIT MOLDS

The initial modeling phase consisted of individually constructing the anatomical structures using biscuit material, including two testicles, epididymis, ductus deferens, penis, and a skin layer, in addition to a support structure designed to stabilize the model (Figure 1).

Figure 1

(A) Biscuit structure representing the penis; (B) biscuit structure designed as the support base; (C) biscuit structure representing the testicle; (D) biscuit structure representing the epididymides and ductus deferens; (E) biscuit structure representing the skin



Source: Prepared by the authors.

All components were fixed onto a base to ensure dimensional stability and facilitate handling during subsequent stages. The molds were allowed to dry for four days in a controlled environment, ensuring adequate structural integrity and resistance. Environmental control was essential to preserve anatomical fidelity and mechanical properties required for future didactic application.

2.4 SILICONE MOLDING TEST

After complete hardening of the biscuit structures, one testicle was selected for a preliminary silicone molding test using general-purpose silicone adhesive (Figure 2). This step aimed to evaluate material behavior during curing, determine the required drying time, and identify potential adjustments for subsequent molding procedures.

Figure 2

Testicular mold produced using general-purpose silicone adhesive



Source: Prepared by the authors.

The resulting mold was stored in a protected environment, without exposure to direct light or manual handling, to prevent deformation or contamination. No release agents, oils, or petroleum-based substances were used, allowing direct assessment of the material's performance.

After a three-day curing period, the mold demonstrated satisfactory structural integrity, although minor imperfections were observed. These findings guided refinements in later stages of the fabrication process.

Following validation of this initial test, the remaining anatomical structures were molded using the same technique, ensuring morphological fidelity and structural uniformity. The previously constructed support base was maintained in its original form and was not subjected to silicone molding, as its structural function had already been achieved.

To improve adaptation to internal components and enhance manufacturing control, the skin mold was developed in two separate parts (upper and lower portions). This approach facilitated the accommodation of internal structures (testicles, penis, ductus deferens, epididymis, and support base), allowed better control of material thickness, improved surface finishing, and reduced deformation during curing.

2.5 FINAL FABRICATION OF INTERNAL ANATOMICAL STRUCTURES

After successful mold development, the molds were used to produce the final anatomical structures. This phase aimed to improve morphological precision and ensure uniformity among the components of the anatomical biomodel.

Clear rubber was used as the primary material and carefully introduced into the molds under controlled conditions, respecting curing time and environmental requirements. The

structures were maintained in a protected environment without direct light exposure or manipulation until complete curing.

This procedure minimized defects such as deformation and air bubble formation. After curing, the structures were carefully removed from the molds, resulting in satisfactory reproduction of anatomical features and preservation of key morphological characteristics. These results confirmed the effectiveness of the technique for producing didactic anatomical models.

2.6 FABRICATION OF THE SKIN STRUCTURE

For the final stage, the external skin structure of the anatomical biomodel was produced using platinum-cured transparent silicone, composed of two components (A and B) mixed in equal proportions according to the manufacturer's instructions.

An initial pilot test was conducted to evaluate the material's mechanical resistance and suitability for surgical simulation, particularly for suturing procedures. This preliminary step confirmed the material's applicability and allowed identification of potential limitations.

Following validation, the definitive mold was prepared. Components A and B were weighed separately (totaling 152 g) and thoroughly homogenized to ensure uniform curing. The mixture was then poured into the mold designed to represent the external skin layer.

To enhance anatomical definition and ensure consistent thickness, the internal portion of the mold was positioned over the still-fluid silicone. The initial attempt did not fully meet expectations regarding structural quality and surface finish. Therefore, adjustments were made, including improved homogenization of the material and better control of mold assembly to reduce air bubbles.

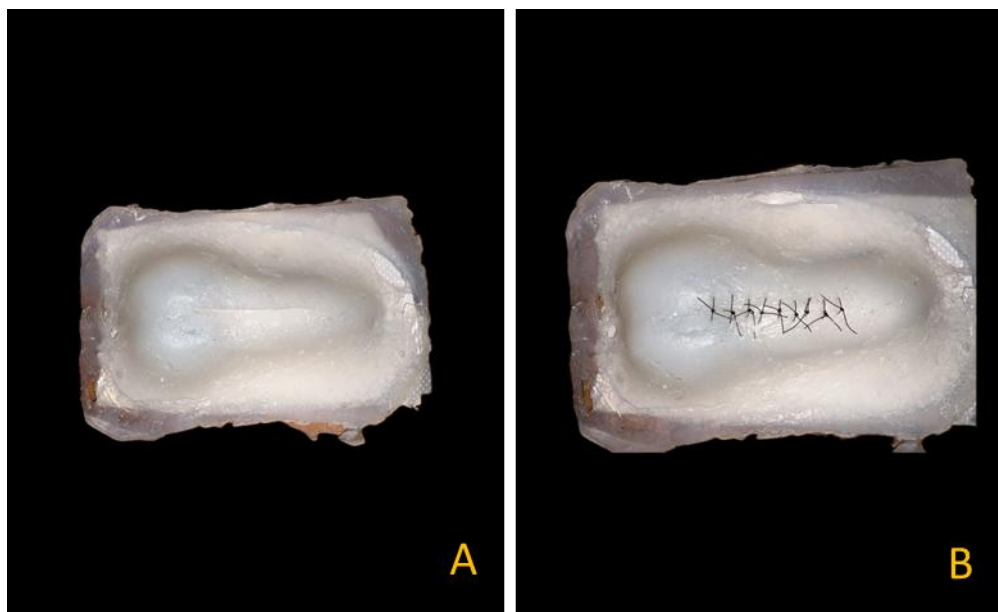
A second fabrication attempt resulted in improved anatomical definition, structural integrity, and mechanical properties compatible with its intended application. The final assembly was allowed to cure for approximately three days in a protected environment, resulting in a structure suitable for integration into the final anatomical model.

2.7 ANATOMICAL BIOMODEL ASSEMBLY AND TESTING

After completion of all components, the full anatomical biomodel of the male canine genitourinary region was assembled and tested in a controlled environment to simulate orchiectomy procedures (Figure 3).

Figure 3

(A) Finalized anatomical biomodel; (B) Appearance of the biomodel after training in the orchietomy technique and suturing



Source: Prepared by the authors.

The model was positioned on a flat surface in dorsal recumbency, replicating standard surgical positioning. Basic surgical instruments, including scalpel, anatomical forceps, needle holders, and scissors, were used.

Incisions were performed on the simulated skin layer to replicate surgical access, allowing exposure of internal structures. Subsequent dissection enabled identification of anatomical components such as testicles, epididymis, and ductus deferens.

The exposed structures were manipulated using surgical instruments to simulate tissue handling, isolation, and exteriorization of the testicle. The procedure followed the fundamental steps of canine orchietomy, including manipulation of the spermatic cord.

Throughout the procedure, standard surgical maneuvers were performed to assess whether the anatomical biomodel allowed adequate reproduction of the technique. The evaluation focused on the feasibility of completing surgical steps, structural resistance, and overall applicability of the model for training purposes.

3 RESULTS AND DISCUSSION

The development of the anatomical biomodel of the male canine genitourinary region demonstrated clear technical feasibility and relevant didactic applicability, indicating that the strategic combination of materials was a determining factor in achieving structures with

mechanical and morphological properties comparable to biological tissues. This reinforces the importance of material selection in the design of synthetic models intended for surgical training, particularly when the objective includes both structural fidelity and functional simulation.

The use of biscuit as a structural support material proved effective due to its dimensional stability, ease of handling, and low cost, making it suitable for the initial modeling phase. In contrast, the application of clear rubber for internal anatomical structures provided greater flexibility and improved tactile feedback, which are essential characteristics for simulating tissue manipulation. These findings support the concept that multimaterial approaches enhance the realism of synthetic models by allowing the reproduction of distinct biomechanical properties within the same structure (Barros; Schmidt, 2019).

The transparent silicone rubber used to simulate the skin layer exhibited adequate resistance to incision and manipulation, allowing the execution of surgical maneuvers without immediate structural compromise. The implementation of preliminary testing was a critical step in refining the fabrication process, as it enabled adjustments that improved anatomical definition and overall uniformity. This highlights the relevance of iterative development and process standardization in the production of biomodels, particularly when consistency and reproducibility are required for educational use.

During the surgical simulation phase, the biomodel allowed the execution of the fundamental steps of orchiectomy, including incision, dissection, identification, and manipulation of anatomical structures. Although the model does not fully replicate the complexity of living tissues—such as vascularization, bleeding, and dynamic tissue response—it provided sufficient fidelity to support the acquisition of procedural knowledge and basic technical skills. This observation aligns with previous findings that emphasize the role of simulation in bridging the gap between theoretical learning and clinical practice (Issenberg et al., 2005).

From an educational perspective, the possibility of repeated practice in a controlled and safe environment represents a significant advantage, as it contributes to the progressive development of psychomotor skills, reduction of procedural anxiety, and increased confidence among students. Furthermore, the use of biomodels directly addresses ethical concerns associated with the use of animals in teaching, aligning with the principles of reduction, refinement, and replacement (3Rs), and supporting a shift toward more sustainable and ethically responsible educational practices.

Despite these advantages, some limitations must be considered. The durability of the materials under repeated use remains a critical factor, as progressive degradation may compromise both structural integrity and simulation quality over time. Additionally, the level of

anatomical detail, particularly in smaller or more complex structures, may not fully match that observed in biological specimens. These limitations suggest that, while the biomodel is effective as a complementary teaching tool, it does not replace the need for exposure to real anatomical conditions.

Future studies should focus on the incorporation of alternative materials with improved mechanical resistance and greater anatomical fidelity, as well as on the validation of the anatomical biomodel through objective assessment methods involving larger groups of students. Quantitative evaluation of learning outcomes and skill acquisition would further strengthen the evidence supporting its educational effectiveness and facilitate its integration into veterinary curricula.

4 CONCLUSION

The anatomical biomodel of the male canine genitourinary region developed in this study proved to be a viable and effective didactic tool for training in the orchiectomy technique.

The combination of materials used enabled the construction of a model with adequate anatomical fidelity and mechanical properties compatible with surgical simulation, allowing the main steps of the procedure to be performed in a safe and reproducible manner.

From an educational perspective, the anatomical biomodel contributes to the improvement of students' technical skills, promoting practical learning in a controlled environment, with reduced errors and increased confidence during the execution of surgical procedures.

Furthermore, its use is aligned with the principles of reduction, refinement, and replacement (3Rs), representing an ethical and accessible alternative to the use of animals in teaching.

Thus, the proposed anatomical biomodel demonstrates strong potential to be incorporated as a complementary tool in veterinary surgical education, contributing to the training of more qualified professionals and to the advancement of innovative pedagogical practices.

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“BECAUSE I LOVED HER SO MUCH”: GENDER-BASED VIOLENCE AND THE REPRESENTATIONS OF THE FEMININE IN THE MANGA TOMIE

“PORQUE EU A AMAVA DEMAIS”: VIOLÊNCIAS DE GÊNERO E AS REPRESENTAÇÕES DO FEMININO NO MANGÁ TOMIE

“PORQUE LA AMABA TANTO”: LA VIOLENCIA DE GÉNERO Y LAS REPRESENTACIONES DE LO FEMENINO EN EL MANGA TOMIE



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ABSTRACT

This article, part of the research conducted for the Master's in Communication (PPGCOM-UFPI, 2025), proposes an analysis of how violence against women and villainy are represented in the manga "Tomie," highlighting the ways in which narratives reinforce cultural and social norms that perpetuate such violence. This work by manga artist Junji Ito, known for his stories of psychological horror and supernatural elements, first published in 1987, revolves around the character Tomie, with the narrative—"an irresistibly beautiful young woman provokes obsession and violence in the men around her." This phrase summarizes the dramatic structure of the work, but also reveals, in deeper layers, a powerful commentary on how patriarchal culture constructs, controls, and punishes the female figure. The research adopted a qualitative approach, with content analysis (Bardin, 2006), observing 12 selected Figures from the manga, which were organized into five categories: 1) femicide, 2) nudity, 3) passion, 4) villainy, 5) male brotherhood, and 6) enchantment. Categories 1, 4, and 5 are analyzed in this article, from the theoretical perspectives of Beauvoir (2014), Segato (2013), Elena Teles and Valeska Zanello (2017), and Alves (2021). The analysis of violence against women in Tomie reveals not only Junji Ito's skill in creating horror narratives, but also his ability to address profound social issues. Through Tomie's story, we are confronted with the reality of obsession, objectification, and violence, themes that continue to resonate in contemporary society. The repetition of Tomie's femicide and her regeneration throughout the narrative suggest a critique of the objectification and blaming of women. Therefore, concrete actions are urgent, considering the exponentially increasing rates of violence against women, producing profound impacts both on individual structures—especially those of female victims—and on the sociocultural dynamics that affect their families and communities.

Keywords: Narratives of Violence Against Women. Feminine Representations. Media. Manga. Tomie.

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RESUMO

O presente artigo, parte integrante da pesquisa realizada no mestrado em Comunicação (PPGCOM-UFPI, 2025), propõe analisar como as violências contra as mulheres e a vilania são representadas no mangá *Tomie*, destacando os modos que as narrativas reforçam normas culturais e sociais que perpetuam tais violências. A obra do mangaká Junji Ito, conhecida por suas histórias de terror psicológico e elementos sobrenaturais. Publicado pela primeira vez em 1987, o mangá gira em torno da personagem *Tomie*, tendo como narrativa – ‘uma jovem irresistivelmente bela provoca obsessão e violência nos homens ao seu redor’. Essa frase resume a estrutura dramática da obra, mas também revela, em camadas mais profundas, um poderoso comentário sobre o modo como a cultura patriarcal constrói, controla e pune a figura feminina. A pesquisa adotou uma abordagem qualitativa, com análise de conteúdo (Bardin, 2006), tendo como observáveis 12 *Figurens* selecionadas do mangá que foram organizadas em cinco categorias – 1) feminicídio, 2) nudez, 3) passionalidade, 4) vilania, 5) irmandade masculina e 6) encantamento, sendo analisadas neste artigo as categorias 1, 4 e 5, nas perspectivas teóricas de Beauvoir (2014), Segato (2013), Elena Teles e Valeska Zanello (2017), Alves (2021). A análise da violência contra mulheres em *Tomie* revela não apenas a habilidade de Junji Ito em criar narrativas de terror, mas também sua capacidade de abordar questões sociais profundas. Por meio da história de *Tomie*, somos confrontados com a realidade da obsessão, da objetificação e da violência, temas que continuam a ressoar na sociedade contemporânea. A repetição de feminicídio de *Tomie* e sua regeneração ao longo da narrativa sugere uma crítica à objetificação e culpabilização da mulher. Portanto, ações concretas são urgentes, considerando os índices de violências contra as mulheres que crescem de maneira exponencial e produzem profundos impactos tanto nas estruturas individuais – especialmente das mulheres vítimas – quanto nas dinâmicas socioculturais que afetam suas famílias e comunidades.

Palavras-chave: Narrativas de Violências Contra a Mulher. Representações Femininas. Mídia. Mangá. *Tomie*.

RESUMEN

Este artículo, parte de la investigación realizada para la Maestría en Comunicación (PPGCOM-UFPI, 2025), propone un análisis de cómo se representan la violencia contra las mujeres y la villanía en el manga "*Tomie*", destacando las maneras en que las narrativas refuerzan las normas culturales y sociales que perpetúan dicha violencia. Esta obra del mangaka Junji Ito, conocido por sus historias de terror psicológico y elementos sobrenaturales, publicada por primera vez en 1987, gira en torno al personaje *Tomie*, con la narrativa: "una joven irresistiblemente bella provoca obsesión y violencia en los hombres que la rodean". Esta frase resume la estructura dramática de la obra, pero también revela, en capas más profundas, un poderoso comentario sobre cómo la cultura patriarcal construye, controla y castiga la figura femenina. La investigación adoptó un enfoque cualitativo, con análisis de contenido (Bardin, 2006), observando 12 imágenes seleccionadas del manga, organizadas en cinco categorías: 1) feminicidio, 2) desnudez, 3) pasión, 4) villanía, 5) hermandad masculina y 6) encantamiento. Las categorías 1, 4 y 5 se analizan en este artículo desde las perspectivas teóricas de Beauvoir (2014), Segato (2013), Elena Teles y Valeska Zanello (2017) y Alves (2021). El análisis de la violencia contra las mujeres en *Tomie* revela no solo la habilidad de Junji Ito para crear narrativas de terror, sino también su capacidad para abordar profundas problemáticas sociales. A través de la historia de *Tomie*, nos enfrentamos a la realidad de la obsesión, la cosificación y la violencia, temas que siguen resonando en la sociedad contemporánea. La repetición del feminicidio de *Tomie* y su regeneración a lo largo de la narrativa sugieren una crítica a la cosificación y culpabilización de las mujeres. Por lo tanto, urgen acciones concretas, considerando el aumento exponencial de las tasas de violencia contra las mujeres, que produce profundos impactos

tanto en las estructuras individuales —especialmente en las víctimas— como en las dinámicas socioculturales que afectan a sus familias y comunidades.

Palabras clave: Narrativas de Violencia Contra las Mujeres. Representaciones Femeninas. Medios de Comunicación. Manga. Tomie.

1 INTRODUCTION

The realization that humanity has historically been defined from a male reference point forces us to rethink fundamental categories of culture, knowledge and politics. This definition is not neutral: it legitimizes inequalities, makes experiences invisible, and sustains power structures that make violence against women possible and recurrent. By questioning this construction, feminism does not seek to invert hierarchies, but to universalize the human in fact, recognizing women – and all marginalized subjectivities – as subjects full of rights, dignity and existence.

Gender violence is a structural phenomenon of society. In 2022, according to the Patrícia Galvão Institute³, femicide data in Brazil increased by 6%, while femicide attempts grew by 17%, these being the highest rates since 2015, the year in which the femicide law came into force in the country. According to DATASSP⁴, from 2022 to 2025, Piauí recorded a total of 182 cases of femicide. In 2024 alone, 56 cases were recorded, representing an increase of 32% compared to the previous year. This year alone, 18 confirmed femicides were registered in March, which indicates a growing trend.

Table 1

Year	Brazil – Femicides (%)	Brazil – Femicide attempts (%)	Piauí – Cases of femicide	Notes
2022	+6%	+17%	182 (2022–2025 total)	Highest rate since 2015
2024	-	-	56	32% increase compared to 2023
Mar/2025	-	-	18	Only in March, growth trend
2015	Initial reference Law 13.104/2015	-	-	Beginning of the Femicide Law
Last decade	11,967 women killed	-	-	Cases have almost tripled in 10 years

Source: Authors.

Almost 12 thousand women have suffered femicide in Brazil in the last decade. In March 2025, Law 13.104/2015, which deals with femicide, completed 10 years, as reported by Gortazár (2025):

The femicides accounted for almost tripled in these 10 years (from 535 to 1,259 deaths). If in 2015 they were only less than two women killed per day, it now reaches four deaths per day at the hands of husbands, boyfriends, etc. Experts attribute this increase to

³ The Patrícia Galvão Institute monitors the dissemination of data and research in Brazil, following the government agencies responsible for this data, the research institutions that work with this theme and the media. Making the data available on the Violence Against Women in Data Platform.

⁴ Center for Advanced Studies in Public Security.

several factors: an increase in violence as women gain autonomy, an increase in complaints, and an increase in registrations.

The data presented show violence against women – female body, constituted from a power that perpetuates submission. This dynamic can be explained, according to Santos and Izumino (2005), through the lens of male domination, a violence that manifests itself as an expression of patriarchy and its tentacles disseminated by institutional means that structure contemporary society, such as the media.

In view of the above, the implementation of the law is crucial for a real mapping and typification of crimes against women. It should be noted that these numbers, although expressive, represent only a part of the reality, as many cases are not reported, and the underreporting of crimes of domestic and family violence is a persistent reality.

It should be noted that Japan, the manga's country of origin⁵, despite having one of the lowest crime rates in the world⁶, The White Report on Gender by⁷ the Japan Office for Gender Equality mentions recent measures: the enactment of a law that in April 2024 expanded the law on the prevention of spousal violence; among other improvements in protection, restraining orders, actions to support victims based on government consultations.

Violence against women is a consequence of historically patriarchal social, cultural, political, and economic structures, which have been consolidated over time and naturalized gender inequalities. These structures establish asymmetrical power relations between men and women, attributing positions of dominance to the masculine and to the feminine roles of subordination, fragility and dependence.

In this context, violence is not an isolated phenomenon or the result of individual behaviors alone, but rather the concrete expression of a system that legitimizes and reproduces control over women's bodies, sexuality, autonomy and lives. The macho culture, gender stereotypes, inequality in access to rights, and institutional omission contribute to the maintenance of these violent practices.

In this way, patriarchal control is reflected in a strong mythology full of legends and stories about the 'feminine that portrays it as monstrous', whether in the representation of seductive and sinful women, or emotionally unbalanced and crazy. One example is the

⁵ Japanese comic books.

⁶ Japan is at the top of the ranking among the least violent countries, with a number that varies between 0.3 (2008) and 0.4 (2009) homicides per 100,000 inhabitants (Moreira, 2013).

⁷ Available at: https://www.gender.go.jp/about_danjo/whitepaper/r07/zentai/pdfban.html?u. Accessed on January 10, 2025.

Japanese folklore entity *Yanagi Baba*⁸, the depiction of a scary old woman reflects the cultural tendency to associate the undomesticated feminine – especially when aged, lonely, or connected to the supernatural – with danger and marginality. In patriarchal societies, the woman who escapes traditional roles (mother, wife, caregiver) is often branded as "monstrous," "witch," or "evil."

From this perspective, this article, an integral part of the research carried out in the master's degree in Communication (PPGCOM-UFPI, 2025), proposes to analyze how violence against women and villainy are represented in the manga *Tomie*, highlighting the ways in which narratives reinforce cultural and social norms that perpetuate such violence. The work of mangaka Junji Ito, known for his psychological horror stories and supernatural elements. First published in 1987, the manga revolves around the character *Tomie*, with the narrative "an irresistibly beautiful young woman causes obsession and violence in the men around her". This phrase sums up the dramatic structure of the work, but it also reveals, in deeper layers, a powerful commentary on the way patriarchal culture constructs, controls, and punishes the female figure.

In *Tomie* (2021), V. 01 and V. 02, we analyze events in which the protagonist, the name of the work, is repeatedly a victim of femicide – but always regenerates from the junction of her limbs that were dismembered – perpetuating the cycles of violence. Despite the numerous attempts at destruction and annihilation, *Tomie* always returns. This supernatural characteristic can be interpreted as a metaphor for female resistance in the face of violence. Even dead, women victims of femicide leave marks: social movements emerge, policies are created, and memories are preserved. *Tomie*, by being reborn, denies patriarchy the absolute power to silence her — and represents the impossibility of eliminating the female presence from history.

Manga is not just Figureic or media entertainment, but a cultural document that materializes social imaginaries. The multibillion-dollar manga industry is not limited to moving expressive figures; It also exerts a deep symbolic and cultural power, configuring itself as a vector for the diffusion of social imaginaries about the feminine. By consolidating itself as one of the pillars of the Japanese cultural economy, manga reaches not only domestic readers, but global audiences, crossing borders through adaptations, merchandising, and derivative media,

⁸ The figure of *Yanagi Baba* – literally "old woman of the willow" – is a deeply symbolic entity of Japanese folklore, associated with nature, time and the feminine imagination. It is a *yōkai* (spirit or supernatural creature) linked especially to ancient willows, trees traditionally associated with mourning, memory and the spirit world in Japan. Available at: https://www.google.com/search?q=representa%C3%A7%C3%A3o+do+Yanagi+Baba+como+uma+mulher+velha+e&rlz=1C1CHZN_ptBRBR1173BR1173&oq=representa%C3%A7%C3%A3o+do+Yanagi+Baba++como+uma+mulher+velha+e&gs_lcrp=EgZjaHJvbWUyBggAEEUYOdIBCDE3MTZqMGo3qAlAsAlA&sourceid=chrome&ie=UTF-8.

such as anime and video games. The manga market in Japan recorded, in 2024, the highest revenue in history: ¥ 704.3 billion (about US\$ 4.6 billion), according to the *Research Institute for Publications*. This represents 44.8% of the entire Japanese publishing sector, consolidating manga as the main force of the cultural industry in the country. The digital format leads this expansion. On the global stage, Japan accounts for about 49.5% of total revenues, with the Asia-Pacific region concentrating more than 85% of revenues. The global manga market is estimated to reach between \$42 and \$47 billion by 2030.

Within this logic of large-scale production, representations of the feminine are simultaneously produced, naturalized, and questioned, reflecting tensions between traditional stereotypes and possibilities of female agency. Thus, manga function as cultural documents, which record historical, social and aesthetic conceptions about the genre, making visible values, fears, anxieties and desires that cross different layers of society. The combination of economic strength and symbolic potential puts manga in a privileged position to study how visual and media narratives shape and reproduce social imaginaries about the feminine, revealing the close relationship between culture, market, and gender constructions.

Therefore, the scarcity of studies in this field underscores the need to broaden the scope of research by integrating popular media, such as manga and anime, with pertinent discussions, which not only fills a gap in our academic knowledge, but also broadens the understanding of how this culture reflects and impacts social and cultural issues of the current reality. Manga, according to Júnior (2005), is a product that is part of a massification, as well as other products of Japanese *Pop Culture* that are sold worldwide, seeking a constant balance in sales and profits, often appealing to appealing, sexual, violent and commonly fictional themes, although others take into account the aspects of everyday life, of the history and culture of a country.

A report presented in 2023 by IMARC, ⁹on "*Manga Market Report by Type (Printed, Digital), Genre (Action and Adventure, Sci-Fi and Fantasy, Sports, Romance and Drama, and Others), Audience (Children and Kids (Aged below 10 years), Teenagers (Aged between 10 to 16 years), Adults (Aged above 16 years)), Gender (Male, Female), Distribution Channel (Online, Offline), and Region 2024-2032*"¹⁰, in which it analyzes the world of manga in the market, pointing out some segments within the industry, namely: reading format, genre, audience (by age), audience (by genre), and region by continent. Better explained in the following table.

⁹ The International Market Analysis Research and Consulting Group – IMARC: offers market research services for various segments.

¹⁰ Manga Market Report by Type (Print, Digital), Genre (Action & Adventure, Science Fiction & Fantasy, Sports, Romance & Drama, and Others), Audience (Children & Youth (Under 10 Years Old), Teens (Aged 10-16 Years), Adults (Over 16 Years Old), Gender (Male, Female), Distribution Channel (Online, offline) and region 2024-2032.

Table 2

Global Manga Market Segments

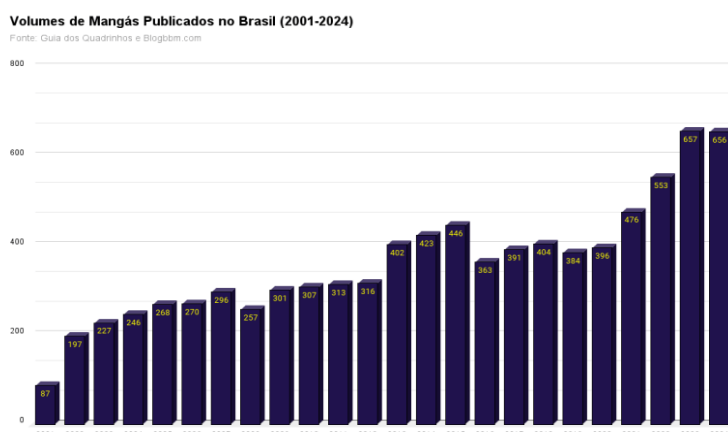
SEGMENT	CATEGORY	HIGHLIGHTS/REMARKS
Audience by Age Group	Children (<10 years)	Important segment; attracted by playful and educational themes (<i>kodomo</i>)
	Adolescents (10 to 16 years old)	Largest segment of readers; strong identification with themes such as friendship and overcoming (<i>shonen</i>)
	Adults (>16 years old)	They represent a significant share; they seek more complex themes
Audience by Gender	Male	Dominant; attracted by male protagonists, plots of overcoming and action
	Women	Growing interest; <i>shoujo</i> and <i>josei</i> titles cater to this audience, but still less expressive in the global market

Source: (IMARC, 2023)

The data presented show a worldwide rise of manga in the various youths and genres. In Brazil, one of the largest consumers in Latin America, we have had a growing increase in manga publications in the last 22 years, as shown in the following Figure:

Figure 1

Volumes of Manga published in Brazil (2001-2024)



Source: <https://blogbbm.com/2025/01/07/numeros-do-mercado-brasileiro-de-mangas-em-2024/>

Editora Pipoca e Nanquim¹¹ is the holder of the largest number of works published by Junji Ito in Brazil, occupying the 6th place in the ranking of volumes published in the year 2024. The publisher, in 2023-2024, published 11 works by Junji Ito: Phantom Zone, The Headless Sculptures, Tombstone Cities, the Alley, Love Dead, Dysmorphics, Crushing Tales, Remina, The

¹¹ Pipoca e Nanquim, initially in 2009 was a *youtube* channel, where the creators, Alexandre Callari, Daniel Lopes and Bruno Zago discussed the world of pop culture: Cinema. Comics among others. In 2016, the friends started an independent comic book publisher, publishing *Swords and Witches*, authored by Esteban Marot, thus Pipoca e Nanquim would be born in the publishing world.

Groaning Enchantment, Deserter's Abode, *Art Book* Grotesque Visions: Junji Ito's Disturbing Art¹² and Holes of Strangeness: 35 Years of Junji Ito's Career (the author's autobioFigurey).

The publisher JBC¹³, which occupies second place in the ranking, also published titles by the author in the period 2023 and 2024, namely: *Black Paradox*, *Decline of a Man*, *Anguish*, *Diário dos Gatos Yon & Mu*.

Although *Tomie* has its publication in 2021, it still occupies the 5th place in sales in *Horror Figureic Novels*, according to the *ranking* available on *Amazon*¹⁴ on April 6, 2024, in the same ranking we have her other works: *Uzumaki* (1998-1999), in 7th place and *The Egocentric Curses of Souichi* (2022) in 9th place¹⁵. It is important to note that these works are periodically reprinted due to high demand. Naturally, with each relaunch, they usually register a significant volume of sales and often lead the marketing rankings.

2 METHODOLOGY – THEORETICAL AND METHODOLOGICAL TRAITS

Qualitative research in communication, according to Bauer and Gaskell (2015), is characterized by the focus on understanding the senses, interpretations and meanings that the subjects attribute to communication practices – the messages, discourses and media practices that are produced, circulate and appropriated by the public in certain cultural, social, historical contexts – in their symbolic, discursive, cultural and social dimensions, rather than prioritizing numbers or statistical generalizations.

The study carried out in the master's degree in Communication (PPGCOM/UFPI) in 2025, was descriptive and analytical, since it allowed us to interpret the symbolic, narrative and visual layers that sustain the normalization of violence and the ambivalences about the feminine as seductive and monstrous, and the meanings attributed to violence and its representations in the manga *Tomie*, by Junji Ito. More than the measurement of data, meanings, symbols and narratives produced by the work were interpreted, understanding it as a cultural manifestation that dialogues with social constructions about the feminine.

¹² This material was launched at the *Comic Con Experience* (2023) in São Paulo, in which the artist was present, for the first time coming to Brazil, to autograph and receive his fans at *the Magic Market* with the publisher Pipoca and Nanquim and a panel on *the Thunder stage*.

¹³ JBC was founded in 1992 as a communication company initially focused on the Japanese-Brazilian community, based in São Paulo. Its original focus included the publication of magazines in Japanese and Portuguese, such as the newspaper *Tudo Bem* and the magazine *Made in Japan*. However, its big leap came in the early 2000s, when it began to publish manga officially translated into Portuguese. Some of them are very famous: *Sailor Moon*, *Neon Genesis Evangelion*, *Death Note*, *Bleach*. Source: <https://blogbbm.com/2025/01/07/numeros-do-mercado-brasileiro-de-mangas-em-2024/>

¹⁴ Available at: www.amazon.com.br/gp/bestsellers/books/7842733011/ref=pd_zg_hrsr_books

¹⁵ Lists are frequently updated, according to sales.

The analytical corpus was the manga *Tomie* (1987) which, as a cultural product, is understood as a social text that produces and reproduces meanings about the feminine. The research examined the work in its entirety, volumes 1 and 2 (Junji Ito, 1987; republished in 2021) The manga revolves around the character *Tomie*, with the narrative – 'an irresistibly beautiful young woman provokes obsession and violence in the men around her'. This phrase sums up the dramatic structure of the work, but it also reveals, in deeper layers, a powerful commentary on the way patriarchal culture constructs, controls, and punishes the female figure. The research adopted the content analysis (Bardin, 2006), having as observable 12 Figures selected from the manga that were organized into five categories – 1) femicide, 2) nudity, 3) passionality, 4) villainy, 5) male sisterhood and 6) enchantment, being analyzed in this article only categories 1, 4 and 5:

1) *femicide* – the term has undergone changes since 1970¹⁶, since its emergence, today it does not mean a way to name "the deaths of women by homicide due to their social condition as women", says Diana Russell (1992). It is important to take into account whether the murder is related to domestic or family violence.¹⁷

4) *Villainy* – portrayed from her ambiguous personality, simultaneously victim and villain. This category seeks to analyze how the work explores the villainization of female characteristics, especially those associated with power and the transgression of gender roles.

5) *Male Sisterhood* – refers to the alliance between men (with female participation), which sustains and legitimizes acts of violence against *Tomie*, and *Enchantment*, a category that shows men to be subjected to a kind of "spell" that leads them to a posture of passivity in the face of their own actions. In other words, the author imposes a condition that evidences an alienation in relation to the conscience and individual responsibility of the killers, where their choices and attitudes are not the result of an autonomous decision, but rather of an external force that prevents them from acting actively and critically on their own reality.

The application of content analysis enabled a systematic and thorough approach in the identification and categorization of the different manifestations of violence and oppression represented in *Tomie*. The choice of analytical categories evidenced the thematic recurrence throughout the volumes. As shown in the following table, which shows how many chapters of each volume show each category with a lot of significance:

¹⁶ The term was first used at the International Tribunal on Crimes against Women in Brussels (1976) by feminist researcher Diana Russell. There was no popularity in the term in other regions of the world. In 1992, Russell co-edited the book *Femicide: The Politics of Woman Killing*, which deepened this definition and consolidated the term in the academic and activist literature. It was used in Latin America for the first time in 1998 to describe the brutal murders of women in Ciudad de Juarez.

¹⁷ Law No. 13,104/2015.

Table 3*Categories of Analysis*

CATEGORY	BACKGROUND	Quantity		
		V.1	V. 2	Total
FEMICIDE	Tomie's recurrent femicide	8	11	19
VILLAINY	The representation of Tomie as a villainous figure allows us to question the demonization of feminine characteristics associated with power and seduction.	14	14	28
MALE "SISTERHOOD"	It explores how the male alliance contributes to the perpetuation of femicide and the normalization of violent behavior in the plot.	15	10	25
NUDITY	Analyzed as an element that goes beyond eroticism, nudity in <i>Tomie</i> can be read both as a form of objectification and vulnerability of the character, exploring the female body as an object of desire and violence.	3	4	7
"MALE PASSION"	It refers to the impulse of male characters to commit acts of violence based on intense emotions, such as jealousy or obsession.	8	7	15
ENCHANTMENT	Men appear to be immersed in a "spell" that positions them as passive subjects in relation to their own actions.	14	14	28

Source: Survey Data. (2024)

3 TOMIE: THE WOMAN AS VILLAIN AND VICTIM

The story revolves around *Tomie*, with the narrative of 'an irresistibly beautiful young woman causes obsession and violence in the men around her', and therefore, suffers repeated femicides and regenerations, which causes terror and obsession to readers. In Brazil, the *Tomie manga* was published in 2021, three decades after its original release in Japan. The work is divided into two volumes, containing a total of twenty chapters: 1) the first volume brings together nine chapters: "*Tomie*," "*Tomie - Part 02 - Morita Hospital*," "*Underground*," "*PhotoFigurey*," "*Kiss*," "*Mansion*," "*Revenge*," "*Waterfall*," and "*Painter*," and 2) the second volume consists of eleven chapters: "*Assassin*," "*Hair*," "*Adopted*," "*Littlefinger*," "*Little Boy*," "*Must*," "*Baba*," "*Certain Reunion*," "*Maniac*," "*Top Model*," and "*Decrepitude*".

In the manga, the story is not presented in a linear way, since each chapter we have a different *Tomie*, it is always a new character interacting with new scenarios and individuals. The story manifests itself as a puzzle that we put together each piece. To better understand Tomie's dynamics, we have separated four essential points: 1) a young woman who suffers brutal

femicide, having her body dismembered by her classmates, 2) she is reborn from each dismembered part, 3) she "seduces" men and provokes a "crazy passion" and 4) female relationship: *tomielization occurs*.

The first chapter, simply titled *Tomie*, establishes the starting point of the plot, presenting the birth of the mystical figure that will accompany the narrative throughout the manga. The story begins in an atmosphere of mourning and mystery at the school where *Tomie* studied, as students and teachers mourn the tragic death of the young woman, who suffered brutal femicide and had parts of her body scattered throughout the city. The crime remains unsolved and without suspects, which intensifies the initial suspense.

What seemed to be a story of loss and tragedy turns into a disturbing event when *Tomie* reappears in the classroom, apparently unharmed and without any memory of what happened, as if her death had never happened.

It should be noted that there are attempts to silence, forget and make gender violence invisible. Ricouer (2007) emphasizes that forgetting is not only an individual failure, but also a political and social act, linked to silencing strategies. The feminist theories bell hooks (2019), Beauvior (2014), Segato (2013) show how women's history has been systematically silenced. Elena Teles and Valeska Zanello (2017) discuss how the media naturalize, erase or trivialize gender violence, transforming femicides into "crimes of passion", selecting according to Hall (2003) the hegemonic representations and narratives that will appear and which will be forgotten.

Regarding femicide, Segato (2018) shows that violence against women not only occurs, but is also systematically forgotten or trivialized by state, legal and media institutions. The author speaks of a "pedagogy of cruelty", in which repetition and institutional neglect make violence something "normalized", contributing to its social oblivion. This moment of *Tomie*'s 'inexplicable' return after femicide marks the beginning of the cycle of violence and resistance. A mix of horror defined by the "death and regeneration" that defines the work, bringing with it an atmosphere of confusion and discomfort for both the characters and the readers. Everyone is wondering, as shown in the following Figure – how is this possible?

Figure 2

Tomie's first appearance after her death



Source: *Tomie*, v. 1, p. 7.

Tomie's *reappearance*, even after being officially confirmed by the police as dead, begins to scare everyone in the class, but not because this event is strange, but because her survival can harm them. The twist that Junji Ito presents to us happens as a flashback in the class walk on the hill of the deity Inari¹⁸. It is revealed how the "accident" that led to *Tomie's murder* happened to and that *everyone* in her class was complicit in the crime.

Tomie's reappearance can be read as a metaphor for the permanence of gender violence – even if women are silenced (or killed), the mark of violence returns, insistent, revealing that the trauma does not disappear. It dialogues with the idea of traumatic memory (Cathy Caruth, 1996) that which was repressed comes back insistently because it was not properly elaborated.

The police, as a state apparatus that confirms death, represents the institutionalization of forgetting: once the death certificate is given, society "closes" the narrative of that life. But Tomie's return denies this closure, revealing the failure of institutions to deal with violence against women. This dialogues with the notion of political oblivion (Paul Ricoeur, 2000): what should be remembered and repaired is erased, but returns as a spectre.

Tomie's *femicide* occurs during the ride when she is pushed off a cliff by her boyfriend Yamamoto in one of his jealousy crises. The young woman is unconscious after the fall and Yamamoto is prevented by Professor Takagi from calling the ambulance so that they would not be arrested, from that moment on everyone in the class accepted to cover up the evidence and disappear with *Tomie's* body dismembering her and hiding her pieces around the city.

¹⁸ In the words of Mendonça (2019), Inari is a deity of rice and Japanese fertility who can take the form of a fox and uses metamorphosis as a harbinger of something.

Doctor Tamura explains that "the dismembered woman has her reproduction similar to planarians" (p. 70), a sense similar to the mythology of the Hydra of Lerna¹⁹, a mythological monster that regenerates when it cuts off one of its heads, two grew in its place). At this point, the author presents us with a scientific explanation for Tomie's reappearance, as shown in the following Figure.

Figure 3

Doctor Tamura explaining how Tomie seems to multiply



Source: Tomie, v. 1, p 70

Tomie is presented as "indestructible". The narrative breaks with the patriarchal conception that killing would be the way to control or silence women. *Tomie* always returns, showing that the female body does not allow itself to be reduced to the destiny of a violated and disposable object. The reappearance of *Tomie* destabilizes the logic of the pedagogy of cruelty (Segato, 2018).

It is important to note that the interactions in the plot have a great focus on *Tomie* and her aggressors, including female characters. "*Tomielization*" shows how gender violence is constructed and internalized in relationships – and among women it is expressed either through rivalry, aesthetic competition or the reproduction of patriarchal norms, because as Beauvoir (2019) states "you are not born a woman, you become one". In the plot, "becoming" is literal and violent, since the woman, in the character of *Tomie*, loses her consciousness and identity, after incorporation, loses her voice and subjectivity. In the manga, this interactive process is called "*tomielization*" – it consists of *Tomie* "possessing" her female victim by incorporating her cells makes her "more beautiful" (Ito, 2021, p. 96), healthier, and all the old physiognomy and consciousness no longer exist.

Tomielization as a process of internalized violence. When *Tomie* "enters" the victim, she erases her previous identity, producing a more beautiful, younger, healthier body — that is, a

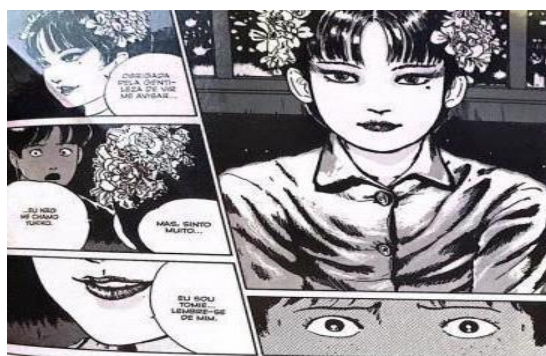
¹⁹ GRIMAL, Pierre. **Dictionary of Greek and Roman Mythology**. Rio de Janeiro: Bertrand Brasil, 1997.

body adjusted to the aesthetic and social norms of femininity, as Naomi Wolf (2018) discusses, about beauty standards and their functioning as control devices over female bodies.

In the chapter *Morita Hospital*, volume 01, in which *Tomie* donates a kidney to the hospitalized girl, and upon receiving it begins to become strong and healthy, until she discovers that she is turning into a monster (*Tomie* regenerating from the organ), as shown in the following Figure.

Figure 4

Yukiko undergoes "tomielization".



Source: *Tomie*, v. 1, p 112

In the chapter *Hair*, volume 02, the friends find strands of shiny hair and a strand attached to Miki Hatawagama's scalp. This is enough for "tomielization" to happen. She begins to resemble *Tomie* – and starts to be admired at school. At the end of the process, the beauty fades away, and becomes monstrous. The strands of hair begin to come out of each pore and cover the entire body, leaving her lifeless, as expressed in the following Figure.

Figure 5

Miki's "Tomielization".



Tomie, v. 2. p 81

The Figure shows the frightened girl, with a wide mouth and eyes, with long strands of hair coming out of her hand and face, from her legs and arms even lifeless on the ground, expressing the monstrous feminine, regenerating again and again. Barbara Creed (1993) problematizes the female monster, expressed in the case of *Tomie*. The fact that she reappears after femicide becomes an inversion of patriarchal destiny: she is not the silent victim, but a disturbing presence that insists on reexisting. The monstrous feminine is born precisely from that which transgresses and threatens the norms of patriarchy.

The woman's body – *Tomie* – as a field of dispute. "Tomielization" shows the female body as a territory of appropriation. The body as a social construction — but in *Tomie*, this construction is radicalized in an annihilation of identity.

Tomie's femicide, in the following Figure, happens recurrently and moves the story, between the real and the supernatural.

Figure 6

Tomie's body discarded in a stream.



Source: *Tomie*, v. 1, p 112

The body of *Tomie* naked, with multiple cuts scattered throughout the body: face, arms, abdomen and back. His neck and arms are submerged in a pool of dark blood surrounded by stones. The scene reflects the trivialization of the woman's body and existence: mutilated and discarded. There are many cases of femicides marked by extreme brutality where "the perpetrator seeks to demonstrate to his peers his capacity for death and cruelty, making explicit in the victims' bodies" (Caicedo-Roa, Bandeira, Cordeiro, 2022, p. 5), such as the femicides that occurred in the *Ciudad Juárez*, in Mexico, of factory workers, cruelly raped to death represents one of the most emblematic cases of femicide in Latin America.

In *Tomie* the cruelty of her femicide, the following Figure, exposes the violence suffered by the character - mutilation, dismemberment, crushing, burning. His face full of cuts, eyes and mouth open, injured arms raised, a cloth with blood stains.

Figure 7

Tomie dead with several cuts on her face



Source: Tomie, v. 1, p 112.

The face, in particular, carries a deep symbolic value: it is on it that the marks of subjectivity, identity and social presence are inscribed. When it is mutilated, erased or destroyed, the intention is communicated to eliminate not only life, but the social and symbolic existence of the victim. As Segato (2013) observes, femicide violence has a pedagogical and disciplinary character, functioning as a message of power and male domination over the female body.

Many cases of femicide are marked by an extreme degree of cruelty: burned, disfigured, cut faces – practices that go beyond the intent to kill. They represent a desire for control, punishment, and silencing.

The mutilated face, in this context, is the erasure of the female gaze on the world, the silencing of her voice and the denial of her autonomy. It is an attempt to "dehumanize" women even after death, reinforcing the idea that their bodies can be the object of possession, hatred or revenge.

For this discussion, we can bring the example of ancient Greece, in which the death of man, as discussed by Martha Nussbaum, in her work *The Fragility of Goodness* (2009), was considered a national tragedy, a civic loss that added a sense of value to the community. The death of the woman, often portrayed in tragedies, symbolized a reaffirmation of her subordination to male authority and the need to maintain the patriarchal order.

The cruelty of female deaths in tragedies was not only a matter of physical violence, but also a profound social message. The brutal forms of murder of women, whether by poisoning, mutilation, or sacrifice, as in plays such as Euripides' *Medea*, were a way of representing that by challenging the patriarchal order, the female body was not only physically destroyed, but also

publicly humiliated, serving as an example to society that female transgression would be mercilessly punished.

As Nancy Sorkin Rabinowitz argues in *Years of Speech: Women and Greek Tragedy* (2008), female death was used as a metaphor for the repression of female potential, a way of showing that women, even in life, were destined to occupy a subordinate space. In other words, her death is less a narrative outcome and more a symbolic device that reiterates the subordinate place of women in the social order.

What we see in *Tomie*, her independence, her desire to continue or not in a relationship is shown as an affront to the man, who decides to take away all the power of choice by murdering her, not only that, but also the cruelty of feminicidal violence is left in sight.

Tomie in her "seductive and fatal beauty", the archetype of the *femme fatale*, whose sexuality can be both admired and feared, according to Mulvey (1975). The facial mutilation - Tomie's disfigured face - shows the impediment to speech, opinion, the public manifestation of the feminine placed as a punishment for her autonomy, interpreted as disobedience. Tomie's beauty, evidenced as seduction and enchantment of men, strengthens the patriarchal and Christian vision.

In volume 2, in the chapter "Nanny", Junji Ito focuses on *Tomie*'s being and evil, in which an elderly couple hire a nanny to take care of their baby, Marina. Upon arrival, the nanny Erita is locked in the room with the child, "because most people run away when they see my baby" (ITO. v. 2, p. 225). Erita removes the child's cloak in the crib and is startled: "This doesn't look like a baby, it's like an exposed heart with a head sprouting from it" (ITO. v. 2, p. 228).

Marina was *Tomie* in the regeneration phase. She cried a lot. The elderly couple went out every night to set the city on fire, because only then would they stop crying "If she doesn't see a fire a day, she gets angry and cries all night" (ITO. v. 2, p. 231). His great pleasure was to see the red color of the fire, the destruction.

The resemblance to the biblical character *Eve - the sinner* - who brought evil to the world, sentenced to condemnation by the male (Christian God) to all women and their future generations. Junji Ito puts *Tomie*, the feminine in this place.

In Figure 6, Junji Ito directs men's actions as involuntary, almost automatic. A "spell". An enchantment. The manipulation of the feminine over the masculine considered as emotionally and psychologically submissive. This perspective builds the Figure of the feminine as manipulative, malefic and villain, transforming it into an archetype of threat, seduction and destruction. This framing perpetuates sexist and misogynistic discourses that seek to justify

violence against women and minimize the responsibility of male aggressors, reinforcing patterns of domination and control in gender relations.

Figure 8

Koji Yamazaki explains about Tomie's bewitching power



Source: *Tomie* (ITO, 2021, Volume 1, p. 125).

In the first frame, we have a woman's serious face, black hair down, with a *voice over* of Tetsuo saying "This girl... Tomie... it has an almost bewitching power. The guys who hang out with her are practically slaves to her will" The main interest to bring this picture and discuss it is in the continuation of the speech "... I don't doubt at all that they will kill someone if it's Tomie's order." In the second, a serious man, with his finger raised, mouth open, saying: "Why are you bewitched by this strange magnetism that she has. I hate to admit it, but I also almost let myself be seduced by her."

The association between femicide and seduction reveals one of the most complex and perverse dimensions of gender violence: the transformation of attraction, desire, and romantic love into devices of control, domination, and death. When femicide is born from relationships marked by seduction — and often by affection — it shows how patriarchal structures naturalize the idea that a woman's body and life can be possessed, controlled, and eliminated when she denies or breaks this pact.

Historically, women were represented as objects of desire and conquest, while men were assigned the role of active subjects, holders of decision and power. In this imaginary, seduction – often idealized as a prelude to love – also works as a gateway to violence. The seduced woman is now seen as possession. The affective bond creates a false sense of entitlement over your body, your choices, and your freedom. When this relationship is threatened - by separation, rejection, autonomy or simple divergence - the frustration of male desire turns into violence.

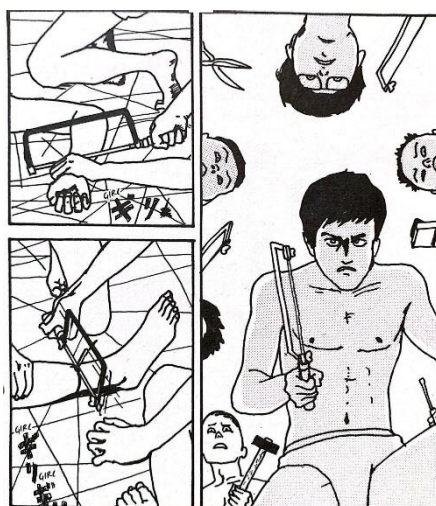
As Segato (2013) states, femicide is not the product of uncontrolled passions, but rather an act of violent reappropriation of a body that the aggressor believes it belongs. In this sense, seduction is the starting point of a process that can culminate in murder when the woman refuses to meet the imposed expectations.

The "seductive woman" is a historical construction that reflects the male gaze on the female body. Elevated to the ideal of femininity and, at the same time, condemned for her sexual freedom, she represents the tension between desire and control that structures patriarchy. When used to justify violence – including femicide – this figure reveals how society transfers the blame for its own victimization to women. Resignifying seduction, therefore, is a political act: it means transforming an instrument of domination into an expression of freedom.

In the following Figure, all the male students naked, holding cutting tools and dismembering *Tomie*, with an expression of anger.

Figure 9

Tomie's death by her classmates



Source: *Tomie* (ITO, 2021, p.).

Femicide with mutilation and dismemberment is not only aimed at biological death. As Segato (2013) analyzes, extreme violence against the female body has a communicative function: it conveys the message that that body does not belong to itself, but to the male domain - and that daring to challenge this domination will be punished with annihilation.

This gesture of brutality also carries a dimension of "exemplary punishment": many victims of femicide dismembered were women who broke off relationships, denounced aggressions, refused to obey or exercised autonomy. The act of dismembering their bodies is the aggressor's attempt to erase female agency—to turn their resistance into eternal silence.

Dismemberment produces more than physical death: it generates a second symbolic death. By removing the integrity of the body, its social and subjective identity is also removed. The woman is reduced to fragments, to the condition of "thing", "object" or "residue". This dehumanization legitimizes violence in the eyes of those who practice it and, often, even of those who narrate it - transforming the victim into something "killable" and "disposable". Butler (2004) calls this condition "precarious life": they are lives that, due to power structures, become less worthy of mourning, less recognized as human. The dismemberment is the maximum expression of this precariousness.

The young women, also accomplices, were responsible for getting rid of *Tomie's body*, each one scattered a part of the body to a different place in the city. Tomie's femicide from the perspective of Segato (2013), in "Scenes of an uncomfortable thought", observes gender violence from two axes that cross each other: 1) the victim-aggressor relationship; 2) the relationship between aggressor and "partners in crime". In the first chapter of Ito's work, there is a strong presence of the second axis: sisterhood, because "Most aggressions against the female body are not committed in isolation" (Idem, 2013, p. 58)

The construction of the Figure of women as victims and villains in cases of femicide reveals one of the deepest contradictions of the patriarchal imaginary and social discourses surrounding gender violence. This double representation is not accidental: it functions as an ideological mechanism of control and disresponsibility, sustaining structures that naturalize violence and blame the woman herself for her death. At the same time that she is portrayed as a fragile and defenseless being – the "ideal victim" – the woman is also transformed into a villain, provocateur and even responsible for the crime she suffered.

The female figure in *Tomie* occupies the role of victim-villain. Function of hiding Tomie's pieces, scattering them around the city at different points, and condoning the crime of her teacher and classmates. The "victim/villain" duality is not a contradiction, but a complementary strategy. Both Figures are used to maintain control over female bodies and behaviors: 1) the woman-victim is exalted because she remains within the expected role and 2) the woman-villain is punished because she transgresses it. In both cases, the patriarchal message is the same: the woman must remain within certain limits - otherwise, her death may be narrated not as a crime, but as a "consequence".

Femicide is not a crime of a man against a woman – it is the project of an entire system, says Segato (2013). The so-called "sisterhood in the crime of femicide" is not only made up of murderers: it includes all those who silence, justify, minimize or ignore violence against women. It is the patriarchal network that sustains femicide as a possible and acceptable practice.

Breaking with this brotherhood requires more than laws - it requires a profound cultural transformation, capable of removing the social and symbolic legitimacy of this crime.

At the end of the first chapter, some of the participants in the murder express the desire to surrender to the authorities, but are pursued by their own companions, who are already taken by madness and the fear of being captured by the police. The "Male Brotherhood", in the chapter *Littlefinger*, the narrator character Hiroya begins the story by telling his relationship with his three older brothers when he was bullied for being short and "far from handsome", this was reflected in his adulthood in which he finds himself with antisocial and self-esteem problems. *Tomie*, in this plot, is the stepmother of the four brothers. After the suicide of their patriarch, Hiroya's brothers "did not look at her (*Tomie*) as a stepmother, but rather as a woman. And she also started to act as if she seduced her stepchildren" (ITO, 2021, p. 126).

This process of eroticization of the maternal role is not natural, but constructed. It originates in the patriarchal logic that reduces women to their sexual and reproductive function, even when they occupy places of care and affection. The stepmother, in this sense, ceases to be a parental figure to become an object of male desire and dispute – including that of children or stepchildren.

As Segato (2013) points out, this type of violence is born not from excessive passion, but from the logic of possession and control, in which the woman who denies male desire challenges the patriarchal symbolic order and, therefore, must be punished. Punishment that *Tomie* suffered again. Once again quartered. The pacts of "Male Brotherhood" take place between the four brothers, with Hiroya being an accomplice in the concealment of *Tomie*'s body.

Figure 10

Horaya comes across Tomie's body dismembered by her siblings



Source: *Tomie* (ITO, 2021, Volume 2, p. 133).

The figure of the stepmother desired by her stepchildren clearly illustrates the patriarchal logic that transforms women into sexual objects, even within family ties. When male desire is frustrated, the answer can be extreme punishment: femicide. Violence, in these cases, is not born of individual feelings, but of a symbolic system that legitimizes possession, naturalizes objectification and punishes female autonomy. By blaming women for their own death, this system reinforces inequality and perpetuates the cycle of violence.

Contextualizing the narrative of this section, *Tomie* was murdered by a group of young men who justify the cruelty by saying: "We ended up dismembering *Tomie*. She mocked us. That's why we killed her" (ITO, 2021, p. 133). Hiroya, despite not participating in the murder, was in charge of disposing of the dismembered body, divided into plastic bags.

4 CONCLUSIONS: *TOMIE* AND THE REPRODUCTION OF FEMICIDE

In 2019, Junji Ito gave an interview to *Grape Japan magazine* where the interviewer asks if there was any inspiration for the creation of the character Tomie, Ito answers:

"No, I'm afraid there wasn't a beautiful woman as a model. When I was in elementary school, a boy in my class died in a traffic accident. It was so strange to me that a colleague so full of life should suddenly disappear from the world, and I had the strange feeling that he would reappear innocently. Since then, I wanted to express this feeling in my manga" (GRAPE JAPAN, 2019, online)

Initially, we did not realize the initial relationship that moved the narrative, but after repeated readings of the material, we understood that Junji Ito's choice to create a female character within the excessive situations of violence was not arbitrary. The theoretical-methodological discussions about women and gender speak of the social construction of the feminine subjugated to the facets of patriarchy. The work directly relates a more advanced stage of a strong subjection of the feminine to the masculine, which culminates in femicide – the impiety after the act, the ruin of a body, the discarded victim, the sale of his flesh as a commodity, the cannibalization of the aggressor, his pieces scattered around the city.

For the narrative to happen, it is necessary that this "monster" be a woman. Junji Ito got it right! The narrative is initially granted to the reader as something close to him, of a tactile experience, where in addition to all the supernatural horror of a seductive and magical mythical woman, we have the cruel as a reality: femicides and other violence against women.

The analysis of the manga *Tomie* allows us to understand femicide not only as a crime, but as a political and cultural act of control over the body and female autonomy. The repeated destruction of the protagonist, motivated by desire, hatred and fear, reveals the symbolic

functioning of patriarchy: to turn women into objects, to punish them when they challenge this condition and, even so, never to be able to erase them completely.

Tomie forces us to face the uncomfortable truth that violence against women – whether in fictional horror or in reality – is no exception, but part of a patriarchal and oppressive system that tries to contain what it fears most: the beautiful, free, intelligent, unsubmitive woman.

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REPORTED CASES OF HIV IN NOVA XAVANTINA – MATO GROSSO – BRAZIL

CASOS NOTIFICADOS DE HIV EM NOVA XAVANTINA - MATO GROSSO – BRASIL

CASOS NOTIFICADOS DE VIH EN NOVA XAVANTINA – MATO GROSSO – BRASIL



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ABSTRACT

The study analyzed the relationship between HIV and the LGBTQIA+ population, focusing on challenges and advances in prevention, as well as the epidemiological reality of Nova Xavantina–MT. The research had a quantitative approach and used data from the Notifiable Diseases Information System (SINAN) covering the period from 2009 to 2025, complemented by interviews with professionals from the Specialized Care Service and Testing and Counseling Center (SAE/CTA). The results showed a higher incidence of cases among men, especially young adults, and a predominance of notifications among heterosexual and mixed-race individuals. It was also observed that factors such as stigma, discrimination, informational inequality, and barriers to accessing health services directly influence testing, early diagnosis, and adherence to treatment. The implementation of SAE/CTA in the municipality resulted in expanded testing, provision of PrEP and PEP, distribution of supplies, and strengthening of educational actions. Despite the advances, structural challenges persist, including funding limitations, inequality in access to specialized services, and ongoing discrimination against LGBTQIA+ individuals and people living with HIV. It is concluded that combined prevention, strengthening public policies, and promoting welcoming strategies are essential to reduce virus transmission and improve the quality of life of vulnerable populations.

Keywords: AIDS. Serology. Prevention. Public Health. Homosexual.

RESUMO

O estudo analisou a relação entre o HIV e a população LGBTQIA+, com foco nos desafios e avanços na prevenção, bem como na realidade epidemiológica de Nova Xavantina–MT. A pesquisa teve caráter quantitativo e utilizou dados do Sistema de Informação de Agravos de Notificação (SINAN) referentes ao período de 2009 a 2025, complementados por entrevistas com profissionais do Serviço de Atendimento Especializado e Centro de Testagem e Aconselhamento (SAE/CTA). Os resultados mostraram maior incidência de casos entre homens, especialmente jovens adultos, e predominância de notificações entre pessoas heterossexuais e pardas. Observou-se também que fatores como estigma, discriminação,

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desigualdade informacional e barreiras no acesso aos serviços de saúde influenciam diretamente a testagem, o diagnóstico precoce e a adesão ao tratamento. A implantação do SAE/CTA no município resultou na ampliação da testagem, oferta de PrEP e PEP, distribuição de insumos e fortalecimento das ações educativas. Apesar dos avanços, persistem desafios estruturais, incluindo limitações de financiamento, desigualdade no acesso aos serviços especializados e continuidade da discriminação contra pessoas LGBTQIA+ e indivíduos vivendo com HIV. Conclui-se que a prevenção combinada, o fortalecimento das políticas públicas e a promoção de estratégias de acolhimento são fundamentais para reduzir a transmissão do vírus e melhorar a qualidade de vida das populações vulneráveis.

Palavras-chave: AIDS. Sorologia. Prevenção. Saúde Pública. Homossexual.

RESUMEN

El estudio analizó la relación entre el VIH y la población LGBTQIA+, con enfoque en los desafíos y avances en la prevención, así como en la realidad epidemiológica de Nova Xavantina–MT. La investigación tuvo un carácter cuantitativo y utilizó datos del Sistema de Información de Enfermedades de Notificación (SINAN) correspondientes al período de 2009 a 2025, complementados con entrevistas a profesionales del Servicio de Atención Especializada y Centro de Pruebas y Asesoramiento (SAE/CTA). Los resultados mostraron una mayor incidencia de casos entre hombres, especialmente adultos jóvenes, y una predominancia de notificaciones entre personas heterosexuales y mestizas. También se observó que factores como el estigma, la discriminación, la desigualdad informativa y las barreras en el acceso a los servicios de salud influyen directamente en la realización de pruebas, el diagnóstico precoz y la adherencia al tratamiento. La implementación del SAE/CTA en el municipio resultó en la ampliación de las pruebas, la oferta de PrEP y PEP, la distribución de insumos y el fortalecimiento de las acciones educativas. A pesar de los avances, persisten desafíos estructurales, incluyendo limitaciones de financiamiento, desigualdad en el acceso a servicios especializados y la continuidad de la discriminación contra personas LGBTQIA+ e individuos que viven con VIH. Se concluye que la prevención combinada, el fortalecimiento de las políticas públicas y la promoción de estrategias de acogida son fundamentales para reducir la transmisión del virus y mejorar la calidad de vida de las poblaciones vulnerables.

Palabras clave: SIDA. Serología. Prevención. Salud Pública. Homosexual.

1 INTRODUCTION

The Human Immunodeficiency Virus (HIV) is a retrovirus belonging to the genus *Lentivirus*, and is an RNA virus that can integrate into the genome of the host cell whose replication depends on the action of the reverse transcriptase enzyme (GAO et al., 1999), this agent acts progressively on the immune system, causing the Acquired Immunodeficiency Syndrome (AIDS) (NGOVENE, 2022). The most affected cells are those that have the CD4 molecule on the surface, such as CD4+ lymphocytes and macrophages. HIV infection occurs when the virus binds to the CD4 molecule and other chemokine molecules, such as CCR5 and CXCR4, present on the surface of cells. This allows the virus to enter the cell and start replicating, some people have a mutation in the gene that encodes the CCR5 molecule, which makes them resistant to HIV infection and are currently known as "elite controllers". Others, who have a different version of this mutation, may have a slower progression of the disease (RACHID; SCHECHTER, 2017).

Its origin is believed to be associated with variants of the Simian Immunodeficiency Virus (SIV), present in non-human primates, especially in the chimpanzee and bonobo of sub-Saharan Africa, with which it shares approximately 98% genetic similarity (GAO et al., 1999). Currently, two main types of HIV are recognized: HIV-1, the most prevalent form of the virus, is the result of the transmission of the Simian Immunodeficiency Virus (SIV) to humans, a process known as zoonosis, responsible for most infections in the world, and HIV-2, which has a lower rate of transmissibility and slower evolution of the disease (NGOVENE, 2022).

This transmission probably occurred when humans hunted and consumed meat from infected primates, exposing themselves to contaminated blood (SHARP; HAHN, 2010). In 1981, in the United States, the first reports of AIDS (Acquired Immunodeficiency Syndrome) emerged, which at the time was a mysterious syndrome that affected healthy homosexuals, characterized by pneumonia and Kaposi's sarcoma (RACHID; SCHECHTER, 2017), but evidence suggests that HIV has been circulating among humans since the 1920s in Central Africa (FARIA et al., 2014). In addition, the spread of HIV has been accelerated by social and economic factors, including urbanization and population mobility. With the increase in international travel in the following decades, the virus spread rapidly around the world (GAO et al., 1999). The global response to this epidemic has been complex and multifaceted, involving efforts in education, prevention, and treatment (SILVA, 2012). Therefore, the origin of HIV is not only a biological issue, it involves an intersection of cultural, social, and historical practices that have shaped its spread and impact on contemporary society (FREEMAN; HERRON, 2009).

People living with HIV face a number of significant challenges, ranging from physical health issues, difficulties in managing the risk of transmission, to social stigmas, intra-family prejudice, and barriers in accessing appropriate care (JESUS et al., 2017). These challenges are often exacerbated by bias and misinformation. Stigmatization can lead to discrimination, making it difficult to seek treatment and social support, which in turn affects treatment adherence and quality of life for affected individuals (BHARAT, 2011).

In recent years, there have been significant advances in HIV treatment, especially in the development of antiretroviral drugs, pre- and post-exposure, which have been fundamental for the control of infection. With the advent of potent antiretroviral regimens and primary prophylaxis for opportunistic infections, not only have the life expectancy of people living with HIV improved (RACHID; SCHECHTER, 2017), but they also reduced the viral load to undetectable levels, which decreases the probability of transmission of the virus (CACHAY, 2024), with this there was a great reduction in the lethality and morbidity associated with HIV, currently, in many countries, the life expectancy of people infected with HIV is similar to that of the general population, as long as they have access to adequate treatment and care (RACHID; SCHECHTER, 2017). However, there are still challenges, such as accessibility and adherence to treatment, which are crucial for the success of epidemic control (CONSELHO FEDERAL DE FARMÁCIA, 2023).

Awareness campaigns play a vital role in educating the population about HIV, helping to demystify the virus and reduce the stigma associated with it. These initiatives are essential to promote prevention, encourage testing, and ensure that people living with HIV have access to treatment and support (LIMA, 2024). Awareness not only improves public health, but also promotes a more inclusive and informed society, in which people can live without fear of discrimination (FREEMAN; HERRON, 2009).

According to Matos and Zöllner (2022), human immunodeficiency virus (HIV) infection continues to be a significant challenge for global public health. This is because HIV can lead to Acquired Immunodeficiency Syndrome (AIDS), paving the way for opportunistic diseases. In Brazil, the HIV situation is influenced by deep-rooted stigmas and constant changes in the profile of people living with the virus, and these changes reflect the evolution of the HIV epidemiological scenario in the country (MATOS; ZÖLLNER, 2022)element.

Another highlight is the identification of informational barriers that can hinder access to HIV-related preventive care and treatment. This research seeks to understand the perception of communities about HIV awareness and prevention campaigns, with the aim of developing more effective and inclusive strategies. The relevance of this study is accentuated by the unique

challenges faced by the LGBTQIA+ population, often exacerbated by stigmas and prejudices. The knowledge generated can inform public policies and promote an equitable approach to health, meeting the specific needs of this community.

In addition, the research seeks to analyze the historical trajectory of HIV, from its discovery to innovations in treatment, allowing an in-depth understanding of the contexts that influence the spread of the virus, to compare the number of individuals categorized with different sexual orientations diagnosed with HIV, to compare regional and national data. Given the current scenario, the work also investigates the relationship between HIV and the LGBTQIA+ population, focusing on the challenges in prevention and treatment. The general objective is to analyze data on the categorized number of heterosexual individuals and the LGBTQIA+ community diagnosed and undergoing treatment at the Testing and Counseling Center (CTA) of Nova Xavantina-MT, seeking to understand the disparities in access to information and health services.

2 THEORETICAL FRAMEWORK

2.1 EPIDEMIOLOGICAL PROFILE OF HIV IN BRAZIL

In recent decades, Brazil has experienced a significant transformation in the profile of the HIV epidemic. There has been a notable growth in incidence among men who have sex with men (MSM), especially among young gay and bisexual men. This trend contrasts with the global scenario, in which HIV infection affects mostly young women. According to UNAIDS data, in 2015, approximately 60% of people living with HIV between 15 and 24 years of age in the world were female (BRASIL, 2022a). Between 2007 and 2016, there was a significant increase in the proportion of HIV cases attributed to transmission among men who have sex with men. According to data from the Ministry of Health, this percentage went from 30.8% to 50.2%, consolidating this group as the most impacted by the epidemic in the country (BRASIL, 2016).

During the period analyzed, there was a reduction in the proportion of HIV cases among heterosexual men, which went from 47.3% to 38.5%, indicating a growing concentration of the epidemic in groups considered more vulnerable. This vulnerability is also expressed in specific age groups: among men aged 15 to 19, the infection rate more than doubled between 2003 and 2015, from 2.9 to 6.9 cases per thousand inhabitants. Among those aged between 20 and 24 years, the rate increased from 18.1 to 33.1 cases per thousand inhabitants in the same interval (BRASIL, 2015).

Recent studies indicate that the growth of HIV infection among young people is related to multiple factors, such as the use of apps that facilitate casual relationships, changes in

conceptions about sexuality, and the absence of consistent educational campaigns, especially in contexts marked by conservatism (KNAUTH; PILECCO, 2024). According to Costa (2016), studies indicate that adolescents who use these apps reported a significant increase in the frequency of occasional sexual intercourse – up to 300% in some urban contexts, according to a survey conducted by UNICEF in partnership with the Ministry of Health.

In addition, according to infectious disease specialist Lígia Kerr, the practice of anal penetration, common among male partners, is pointed out as having a higher biological risk of HIV transmission due to the greater fragility of the anal mucosa and the higher viral load present in male semen (COSTA, 2016). Such physiological factors, combined with social barriers, contribute to the high prevalence of infection among gay and bisexual men in Brazil.

The Ministry of Health, through the Department of HIV, AIDS, Tuberculosis, Viral Hepatitis and Sexually Transmitted Infections of the Health Surveillance Secretariat (Dathi/SVSA), released data from the epidemiological bulletin of HIV and AIDS (2024), and the male category was found with about 6538 homosexuals, 1392 bisexuals, 4381 heterosexuals and the female category with 4541 heterosexuals infected with HIV in 2024, thus, the distribution of the disease proposed by sexual orientation (LGBTQIA+) is clear. The LGBTQIA+ and heterosexual population have other aspects such as transmission by injecting drug use, hemophilia, transfusion, work accidents, vertical transmission addressed.

This trend reinforces the need to intensify actions aimed at combined prevention, with a specific focus on the LGBTQIA+ population, especially among young people, and public policies that ensure equal access to information, testing, PrEP, PEP and continuous treatment, according to SUS guidelines and UNAIDS guidelines.

2.2 HIV PREVENTION

Combined HIV prevention is a comprehensive approach that seeks to reduce new HIV infections by combining biomedical, behavioral, and evidence-based human rights-based strategies. This includes offering individual options for HIV prevention, such as pre-exposure prophylaxis (PrEP), post-exposure prophylaxis (PEP) and consistent condom use. In addition, it is essential to promote behavioral changes, such as regular HIV testing, adherence to antiretroviral therapy (ART), and harm reduction. Structural strategies are also essential, including full and non-discriminatory access to quality health services, public policies that promote gender equality, and the protection of human rights. By combining these approaches, we can achieve maximum impact in reducing new HIV infections and promoting healthier and safer lives for all (UNAIDS, 2025a).

In Brazil, the Department of STI, HIV/AIDS and Viral Hepatitis offers recommendations for health professionals, workers and managers for the planning and implementation of combined prevention actions, considering the specific needs of different key and priority populations (BRASIL, 2025a).

2.3 ACCESS TO AND USE OF HEALTH SERVICES

Discrimination and prejudice are significant barriers to equity in access to health services, involving processes of categorization, labeling, and stereotyping that lead to social rejection and exclusion of vulnerable groups. The impact of discrimination on health is profound, related to anxiety disorders, depression, and post-traumatic stress, as well as negatively affecting access to health goods and services. In addition, stigma is not limited to specific population groups, but also to diseases and health needs, such as "neglected" diseases, challenging health policies and actions and impacting the search for therapeutic help and treatment adherence. To overcome these challenges, it is essential to adopt intersectional and decolonial approaches, recognizing the complexity of experiences of discrimination and promoting broader and more inclusive meanings of social justice, valuing diversity and promoting well-being as a common good (IRIART; CASTELLANOS, 2023).

The Brazilian population faces significant challenges in accessing health services, especially those who are most vulnerable (SOPELETE; BISCARDE, 2013). The National Primary Care Policy seeks to ensure universal and continuous access to quality and problem-solving health services, but there are still significant barriers, such as lack of geographical, financial, and organizational access. In addition, discrimination and prejudice are also significant obstacles to access to healthcare. To overcome these challenges, it is essential to understand the perspective of users and actively involve them in the decision-making process about health. The construction of a user-centered caring attitude is essential to ensure that health services are problem-solving and of quality. In addition, the professional training of health workers also needs to be reviewed to ensure that they are prepared to meet the needs of users in an effective and respectful manner (SOPELETE; BISCARDE, 2013).

Access to health services is a complex concept that involves not only the availability of services, but also people's ability to access and use them effectively. Accessibility is a feature of the provision of services that facilitates or limits use by potential users. Access, on the other hand, is the way people perceive accessibility and is influenced by individual factors, such as the perception of health needs, and contextual factors, such as the organization of health services. The use of health services is a complex process that involves the interaction between

individuals, service providers and the health system. The explanatory models of the use of health services highlight the importance of considering individual factors, such as the perception of health needs, and contextual factors, such as the organization of health services. In addition, it is essential to consider the distinction between the explanatory models of health and the use of health services, as health is a broader phenomenon than disease and cannot be explained solely by the use of health services (TRAVASSOS; MARTINS, 2004).

2.4 STIGMA AND DISCRIMINATION AGAINST PEOPLE LIVING WITH HIV

According to UNAIDS (2021), stigma and discrimination around HIV profoundly affect the health, life and well-being of people living with the virus or who are at risk of contracting it, especially in key populations. These problems create significant barriers to access to prevention, sexual and reproductive health, testing and treatment services. Stigma can manifest itself in the form of hearsay, verbal abuse, and social exclusion, while discrimination can include physical abuse, denial of services, loss of employment and educational opportunities, or even detention. According to UNAIDS (2021), up to 21% of people living with HIV have been denied health services in the last 12 months, and 47 countries still maintain travel restrictions for these people. The consequences include job loss, workplace violence, and discrimination in education. In addition, people who perceive high levels of stigma tend to delay initiation of treatment, and programs that address these issues improve access to HIV services. It is recommended to repeal laws that perpetuate stigma and discrimination, ensuring free and informed consent, privacy, confidentiality, and prohibiting mandatory HIV testing (UNAIDS, 2021).

Stigma and discrimination are complex problems that affect the health and well-being of people, especially those living with stigmatized conditions such as HIV/AIDS, mental illness, or physical disabilities. The individualized approach to stigma, which focuses on the psychological and social effects on stigmatized individuals, is not enough to understand and combat the problem. It is necessary to consider the social and structural dimensions of stigma, including power relations, social hierarchies, and public policies that perpetuate discrimination. In addition, it is essential to address stigma in conjunction with other forms of discrimination, such as racism, sexism, and homophobia, to develop effective prevention and combat strategies (MONTEIRO et al., 2013).

2.5 STIGMA AND DISCRIMINATION

Homophobia, biphobia, and transphobia are forms of prejudice and discrimination that affect people based on their sexual orientation or gender identity. Homophobia is the fear or aversion to lesbian, gay, or bisexual people, whereas biphobia is specific to bisexual people. Transphobia, in turn, is directed at transgender or non-binary people. These biases can manifest themselves in a variety of ways, including *bullying*, discriminatory language, and denial of rights. It is essential to understand and recognize these forms of discrimination in order to build a more inclusive and egalitarian society. Additionally, it is important to combat homophobic, biphobic, and transphobic language, which can be used to discriminate against and marginalize individuals based on their sexual orientation or gender identity (GOMES, 2023).

The mental health of LGBTQIA+ people is deeply affected by homophobic prejudice, which can generate psychological suffering, anxiety, depression, and even suicidal thoughts. Constant exposure to discriminatory and violent attitudes can lead to a permanent state of vigilance, making it difficult to build a healthy and authentic identity. In addition, the lack of acceptance and family and social support can aggravate mental health problems, making it essential to create safe and welcoming spaces for these people to express themselves and seek help without fear of judgment or rejection. The impact of homophobia on the mental health of LGBTQIA+ people can also manifest itself in the form of chronic stress, low self-esteem, and difficulties in establishing healthy relationships. In addition, the internalization of homophobia can lead to feelings of guilt, shame, and self-hatred, making the process of building a positive and authentic identity even more challenging. It is essential that mental health professionals are trained to address these specific issues and offer welcoming and non-judgmental support for these people (SANTOS; LIMA, 2022).

Discrimination against LGBTQIA+ people is a painful reality that affects all areas of life. It is born from deep prejudices, such as homophobia, biphobia, transphobia and interphobia, which are fueled by cisheteronormativity, a worldview that privileges cisgender and heterosexual sexual identities and orientations. This discrimination has devastating consequences on the mental health and well-being of LGBTQIA+ people, leading to problems such as depression, anxiety, and stress. In addition, it manifests itself in a cruel way at different stages of life, from adolescence, when young people face difficulties in acceptance, to old age, in which elderly LGBTQIA+ people suffer a double stigmatization, related to age and sexual/gender identity (GATO, 2022).

The transgender population in Brazil faces a cruel reality of discrimination and stigma, which profoundly affects their mental health and well-being. According to a UNAIDS study,

90.3% of the "trans" people interviewed have experienced situations of stigma or discrimination because of their gender identity. This includes discriminatory comments, verbal harassment, exclusion from family activities, and physical aggression. In addition, the "trans" population is more vulnerable to health problems, such as sexually transmitted infections, tuberculosis and hepatitis. Social exclusion and discrimination also exacerbate several mental health problems (United Nations, 2020).

The HIV/AIDS epidemic continues to hit the LGBTQIA+ community in Brazil hard. According to UNAIDS, about 920,000 people live with HIV in the country, and AIDS kills ten times as many members of the LGBTQIA+ community as violence. The prevalence of HIV infection is high among gay men and other men who have sex with men (18%), and among transvestites, transsexuals and transgender people (30%). However, the LGBTQIA+ community still faces many challenges to speak openly about HIV/AIDS, due to stigma and discrimination. It is essential that the community embraces the issue and works to overcome stigma and discrimination, ensuring equal access to HIV prevention, diagnosis, and treatment (United Nations, 2021).

2.6 PUBLIC POLICIES FOR HIV PREVENTION AND TREATMENT: ANALYSIS OF NATIONAL AND INTERNATIONAL INITIATIVES

HIV prevention is a complex challenge that requires a multifaceted approach. The "Treatment as Prevention" (TcP) strategy is a central approach to achieving the goal of eliminating AIDS by 2030. TcP is based on the idea that early testing and antiretroviral treatment can significantly reduce the risk of transmission of the virus. In Brazil, the government has made a commitment to implement TcP, with the goal of testing 90% of the population with HIV, treating 90% of positive cases, and keeping 90% of people on treatment with an undetectable viral load. To achieve this goal, it is essential to promote large-scale testing, especially among the most vulnerable populations, such as men who have sex with men (MSM). In addition, it is necessary to overcome the challenges of implementing TcP, such as guaranteeing human rights and reducing barriers to access to health services (SOUZA et al., 2019).

The Brazilian response to the AIDS epidemic was marked by a series of innovative public policies, initiated in the 1980s. During this period, the country was experiencing a process of redemocratization and health reform, which culminated in the creation of the Unified Health System (SUS) in 1988. The AIDS epidemic was one of the main challenges faced by the SUS, leading to the creation of the National STD and AIDS Program (PN-DST/AIDS) in 1986. The PN-STD/AIDS was fundamental for the structuring of an HIV/AIDS care network in Brazil,

including prevention, diagnosis and treatment actions. In addition, the program had the financial support of the World Bank, which allowed the expansion of outpatient and hospital care actions. Today, Brazil is an international reference in the fight against AIDS, with a network of services that includes Testing and Counseling Centers (CTA), Antiretroviral Drug Dispensing Units (MDU) and laboratories for counting T lymphocytes and HIV viral load (VILLARINHO, et al., 2013).

2.7 PERSISTENT CHALLENGES: STIGMA, DISCRIMINATION, ACCESS TO SERVICES AND FINANCING.

Even after more than four decades of global response to HIV, stigma and discrimination remain central barriers faced by people living with the virus. A UNAIDS interview (2025) revealed that more than half of the people interviewed (52.9%) reported having suffered discrimination due to positive serology throughout their lives. This exclusion is manifested in several spaces: within the family itself (34.8%), in health services (13.1%) and in situations where confidentiality about the diagnosis may be compromised (46.1%) (UNAIDS, 2025c). Such practices contribute to emotional illness: with a high incidence of symptoms of depression, anxiety, and weaken engagement in treatment, making it difficult to achieve the global goals for the elimination of AIDS as a public health problem (BRASIL, 2025b).

According to a UNAIDS report, HIV-related stigma is structural, affecting not only HIV-positive individuals, but also key populations, such as LGBTQIA+ people, sex workers, drug users, and people in situations of social vulnerability (UNAIDS, 2021). These populations face social rejection, violence, job loss, educational exclusion, and even denial of access to essential health services. Discrimination is also institutionalized through punitive legislation and abusive practices, such as compulsory testing, requiring contraceptives to access treatment, and travel restrictions (UNAIDS, 2021).

Access to health services aimed at the prevention, diagnosis, and treatment of HIV and other STIs in Brazil is guaranteed by the Unified Health System (SUS), which operates under the principles of universality, integrality, and equity. The structuring of the health care network includes the provision of rapid testing, counseling, dispensing of antiretrovirals, clinical follow-up and educational actions, and is organized in a decentralized manner among the federative entities (UNAIDS, 2025d).

Despite the wide coverage provided for in the rule, effective access still presents regional and structural inequalities. Vulnerable populations, such as LGBTQIA+ people, sex workers, drug users, homeless people, people deprived of liberty, and indigenous people, face social and

institutional barriers that make it difficult to remain in services and adhere to treatment (BRASIL, 2025c). Such obstacles range from the lack of trained professionals to welcome without discrimination to limitations in infrastructure and material resources in the municipalities.

The Ministry of Health, through specific financial incentives and the publication of technical guidelines, advises that services implement actions articulated with primary care, specialized centers (SAE/CTA) and psychosocial support networks. Municipalities and states, in turn, must ensure the inclusion of these actions in health plans and programs, ensuring continuous and humanized care for people living with HIV (BRASIL, 2025c).

In addition, it is recommended that active testing and tracing practices be strengthened in the territories, with a focus on expanding early diagnosis and combined prevention, which involves the use of condoms, PrEP, PEP, harm reduction and regular testing. Expanding the coverage of services, especially in municipalities with the highest incidence, is considered strategic for controlling the epidemic (AGGIO, et al., 2025).

The financing of HIV/AIDS surveillance, prevention and control actions in Brazil occurs through a financial incentive instituted by the Ministry of Health, linked to the Variable Floor of Health Surveillance (PVVS). This incentive was initially implemented in 2002, with resources from an agreement with the World Bank, and since then it has been updated according to the epidemiological and operational needs of the country. In 2024, the incentive now has an annual budget of R\$ 300 million, of which R\$ 200 million are specifically allocated to actions related to STIs, HIV, AIDS and viral hepatitis, as established by Ordinance GM/MS No. 4,869/2024 (CONASS, 2024).

The resources transferred are intended to fund strategic actions involving prevention, diagnosis, treatment and monitoring of people living with HIV. These amounts do not replace the resources already allocated by the state and municipal spheres, but complement them, reinforcing the local response capacity. The execution of these resources requires actions to be foreseen in the official planning instruments, Health Plan and Annual Health Programming (PAS) and are monitored through quarterly and annual reports, such as the RQPC and the RAG, ensuring transparency and effectiveness in the application (CONASS, 2024).

In addition, the importance of intersectoral and civil society participation in the planning and execution of funded actions is highlighted, especially in addressing the social vulnerabilities that aggravate the epidemic. The regulation directs that resources should also be directed to key populations, such as men who have sex with men, transgender people, drug users, homeless people and people deprived of liberty, according to the reality of each territory (CONASS, 2024).

The constitutional guarantee of the right to health in Brazil, affirmed in article 196 of the Federal Constitution (2025), supports the free supply of antiretroviral drugs through the Unified Health System (SUS), as established by Law No. 9,313/1996. However, the realization of this right has often been driven by lawsuits, a phenomenon known as judicialization of health. Although this action of the Judiciary has contributed to expanding access to treatment, it has also generated significant consequences in the State's financial planning (FILHO, 2013). Judicial determinations that impose the supply of medicines, often of high cost and not included in the official lists of the Unified Health System (SUS), cause the immediate redirection of public resources, usually without the proper budget forecast. This practice has generated significant impacts on government finances, resulting in the reallocation of funds destined to other equally priority sectors of public health. Research indicates that, if this situation continues, the continuity of the policy of access to HIV/AIDS treatment may be compromised, unless the country presents consistent economic growth or promotes a profound restructuring in its budget and industrial policy, with emphasis on strengthening the national production of generic drugs (FILHO, 2013).

According to Filho (2013), the Judiciary has recognized the supply of medicines as an obligation shared between the Union, States and Municipalities. However, this co-responsibility, although legally supported, is not accompanied by effective mechanisms of financial coordination between the federative entities, which intensifies the challenges faced by local health systems.

Therefore, although judicialization represents a legitimate mechanism to guarantee fundamental rights, its disjointed use of technical and economic criteria can generate imbalances in the execution of public policies. The challenge lies in reconciling individual rights with the rational management of the public budget, especially in contexts of fiscal crisis and high demand for high-cost treatments.

UNAIDS (2025e), published a global report showing that, by the end of 2024, the joint efforts of governments and communities had reduced new HIV infections by 40% and AIDS-related deaths by 56% compared to 2010. However, gaps in prevention remained, with about 1.3 million new cases in 2024 alone. Despite scientific advances, such as long-acting drugs for prevention, the global response suffered a severe impact in 2025 due to the sudden withdrawal of international funding, especially from PEPFAR, which is responsible for 80% of the funding of prevention programs in low- and middle-income countries. UNAIDS estimates that if funding is not restored, by 2029 there could be an additional 6 million new infections and 4 million additional AIDS-related deaths.

The financial crisis has exposed regional and population inequalities: Sub-Saharan Africa has made significant progress but still accounts for the majority of cases, while regions such as the Middle East, North Africa, and Eastern Europe have seen growth in infections. In addition, adolescent girls, young women, and key populations remain more vulnerable, facing stigma, discrimination, and legal barriers. The disruption of funding also affected the distribution of condoms, male circumcision programmes and access to pre-exposure prophylaxis (PrEP), the global reach of which was far below the target for 2025 (UNAIDS, 2025e).

About 25 countries out of 60 have already announced increased domestic investments in HIV by 2026, signaling a transition to more sustainable, albeit gradual and challenging models. The strengthening of health systems, the integration of services and community participation are pointed out as fundamental axes for the sustainability of the response. UNAIDS emphasizes that, although the current crisis represents a setback, it is still possible to achieve the goal of eliminating AIDS as a public health threat by 2030, provided that there is renewed political commitment, multilateral cooperation and diversification of financing mechanisms (UNAIDS, 2025e).

3 OBJECTIVES

3.1 GENERAL OBJECTIVE

To organize and analyze quantitative data categorized into sexual orientation, sex, sexual frequency, age group, education and race, of people who are diagnosed with HIV and undergoing treatment at the Testing and Counseling Center (CTA) of Nova Xavantina-MT, analyze the confrontation of the municipality of Nova Xavantina with HIV/AIDS and compare these actions and characteristics in the national context.

3.2 SPECIFIC

- To ascertain the number of people with different sexual orientation in relation to the diagnosis of HIV and the treatment received in the municipality of Nova Xavantina-MT.
- To analyze the confrontation of HIV/AIDS in the municipality of Nova Xavantina and to compare these actions and characteristics in the national context.
- Identify the main informational barriers that hinder access to HIV-related preventive care and treatment.

4 MATERIAL AND METHODS

4.1 FIELD OF STUDY

The study was carried out in the municipality of Nova Xavantina, in the central-west region, latitude 14° 40' 24" S, longitude 52° 21' 11" W, altitude 275m (GEOGRAFOS, 2025), located in the State of Mato Grosso, 653 km from the capital, Cuiabá. The city has a territorial extension of 5,492.206 km², has an estimated population of 25,915 inhabitants (Brazilian Institute of Geography and Statistics (IBGE), 2025).

4.2 STUDY DESIGN

This is a scientific study, with exclusively quantitative use, through the analysis of data from notifications of patients diagnosed with HIV/AIDS in Nova Xavantina-MT sent by the Regional Office of Barra do Garças-MT, responsible for this STI department in the region. For the bibliographic reference, a theoretical survey was carried out on the origin, characteristics, treatment of HIV/AIDS, and information about the LGBTQIA+ population through bibliographic consultations on virtual platforms such as Scientific Electronic Library Online (SciELO), Google Scholar and electronic addresses of the Ministry of Health, UNAIDS.

4.3 DATA COLLECTION

Notification data from the database of the Notifiable Diseases Information System (SINAN) of the Ministry of Health were requested via email and made available in the form of a spreadsheet by the Regional Health Department of Barra do Garças/MT (May 2025), located in the central-west region, latitude 15° 53' 24" S, longitude 52° 15' 24" W, altitude 318m, area of 8761.3 Km², approximately 516m from the capital Cuiabá, the center responsible for coordinating health actions in the region, including the municipality of Nova Xavantina – MT. It should be noted that, as this is sensitive information, the collection and processing of this data was carried out exclusively by authorized professionals, respecting the principles of confidentiality and ethics, as recommended by the guidelines of the Ministry of Health (Law 14.289/22, Agência Câmara de Notícias, 2022 (BRASIL, 2022b). The number of carriers by sexual orientation, children, education, age group, race, sexual relations, residence, and sex, for the period from 2009 to 2025, was provided. The interview was conducted with the infectious disease specialist in charge at the time (May 2025) from Nova Xavantina, and recorded for proper notes, for information about the CTA, questions in docs were sent via WhatsApp to the current coordinator (May 2025), answered and returned in docs by the same application.

4.4 DATA ANALYSIS

The data obtained in May 2025, through the Regional Health of Barra do Garça/MT were organized and interpreted according to each classification, and through NAPKIN AI, tables and figures were created in order to facilitate the understanding of the data obtained from the Regional Health Department.

5 RESULTS AND DISCUSSION

The municipality of Nova Xavantina, located in the interior of Mato Grosso (653 km from the capital Cuiabá), with approximately 25,915 inhabitants (IBGE, 2025), had an important milestone in August 2023, when the SAE/CTA was implemented in the municipality. The Specialized Care Service (SAE) and the Testing and Counseling Center (CTA) were implemented in the municipality of Nova Xavantina – MT with the purpose of expanding access to diagnosis and early treatment of Sexually Transmitted Infections (STIs), such as HIV/AIDS, syphilis and viral hepatitis B and C. This implementation arose from the need to offer free rapid testing services, provide prevention inputs, promote educational and awareness actions, in addition to ensuring welcoming, confidential, and quality care (SAE/CTA COORDINATION, 2025).

The creation of the SAE/CTA brought significant impacts to local public health, especially in the care of people living with HIV/AIDS and other STIs. Among the main benefits are increased access to diagnosis and treatment, intensification of preventive actions, reduction of STI transmission, mental health care, integration with other health system services, reduction of social stigma and consequent improvement in the quality of life of users (SAE/CTA COORDINATION, 2025).

The target audience of the SAE/CTA covers the entire community of the municipality of Nova Xavantina, with special attention to vulnerable groups, such as young people, adults, the elderly, pregnant women not tested during prenatal care, patients diagnosed with tuberculosis, partners of people with STIs, users of pre-exposure prophylaxis (PrEP), people deprived of liberty, indigenous population, LGBTQIAPN+ population, sex workers, individuals with clinical suspicion or undetermined clinical conditions, victims of sexual violence, adolescents from 15 years of age in this condition, and workers exposed to biological material (COORDENAÇÃO SAE/CTA, 2025).

The SAE/CTA of Nova Xavantina has future prospects to include the expansion and improvement of its activities, with emphasis on the prevention, early diagnosis and treatment of STIs, HIV/AIDS and viral hepatitis. The service already plays a fundamental role and with

excellence in specialized care and intends to further strengthen the integration with primary care, ensuring humanized, equitable and accessible care, especially to the most vulnerable populations. The main goal of the SAE/CTA is to expand access to STI prevention, testing, and treatment actions, with a focus on reducing the incidence of new infections, improving the quality of life of the people served, and combating prejudice and discrimination (COORDENAÇÃO SAE/CTA, 2025).

Its services offered, it uses different means of communication, such as social networks (mainly Instagram), informative pamphlets, campaigns to the public such as at the university of the municipality, schools, squares, some events, and reports on the local radio. These strategies aim to increase the visibility of the service and encourage the population to spontaneously seek testing and counseling (COORDENAÇÃO SAE/CTA, 2025).

An interview was conducted with the infectious disease specialist responsible for the CTA (May 2025). The professional informed that all patients, regardless of sexual orientation, who undergo treatment and follow-up at the city's CTA receive medication. He stressed, however, that not everyone uses the same drug, as there are cases of mutations of the virus and specific situations. For example, some elderly patients (over 50 years old) may receive a new medication in a single daily dose (only one tablet).

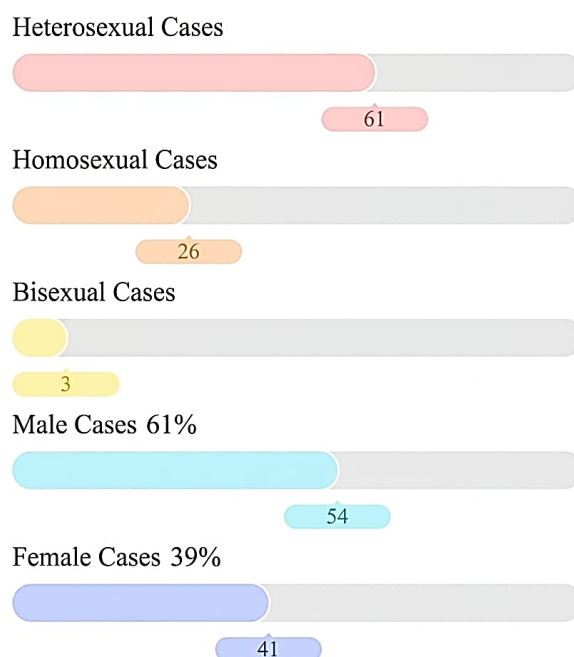
The infectious disease specialist also explained about the treatment of pregnant women, noting that they follow the protocol considered "normal". However, there are changes in pregnant women in the first trimester who have not yet started first-line treatment, due to studies carried out by a university in the United States that raised the hypothesis that dolutegravir is associated with nuchal translucency in fetuses.

During the interview, the doctor was asked about the medication intended for people with AIDS, considering that HIV and AIDS are not the same condition. The question was whether there would be a difference in the drugs used. The specialist clarified that the treatment is the same, since Acquired Immunodeficiency Syndrome (AIDS) corresponds to the advanced stage of HIV infection, usually after a period of 7 to 10 years without treatment. The data made available by the Regional Health Department of Barra do Garças follow the respective records, among heterosexual people (61), followed by 26 cases among homosexual people and 3 among bisexuals (figure 1). In addition, one case of perinatal transmission was recorded, highlighting the importance of prenatal care for the prevention of vertical transmission of HIV. Regarding the distribution by sex, there was a predominance of males, with 54 reported cases (61%), while females (39%) represented 41 records (Figure 1).

Figure 1

Distribution of HIV/AIDS cases by sex and sexual orientation

Distribution of HIV Cases by Gender and Sexual Orientation

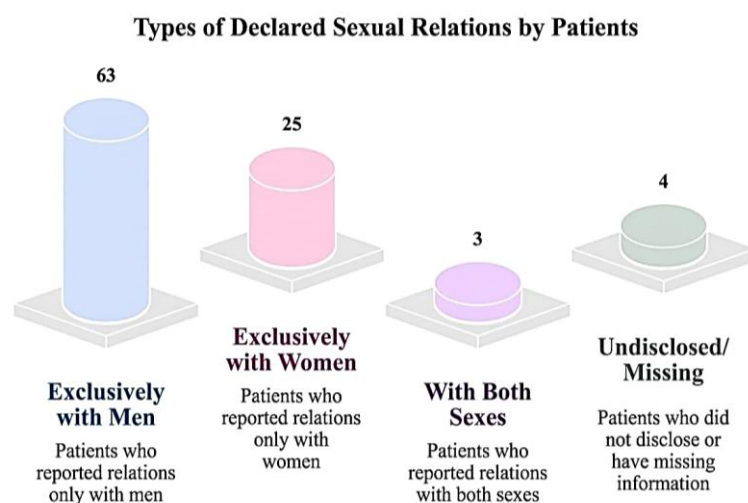


Source: Data: provided by the Regional Health of Barra do Garças/MT. Image: The authors.

The data provided also present information regarding the types of sexual relations reported by the patients. A total of 63 people reported having sex exclusively with men, 25 reported having sex exclusively with women, and 3 reported having sex with both sexes. In 4 cases, this information was not declared or is missing (unknown/blank) (figure 2). It should be noted that these data do not necessarily indicate the sexual orientation of the individuals nor are they directly related to biological sex, reflecting only the types of sexual partners mentioned at the time of notification.

Figure 2

Distribution of HIV/AIDS cases by self-reported sexual intercourse

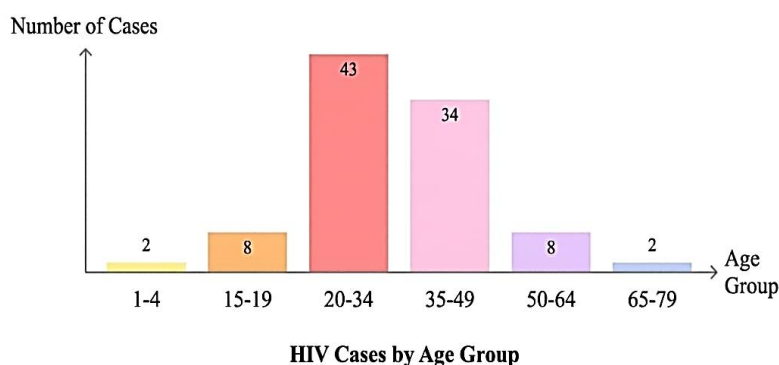


Source: Data: provided by the Regional Health of Barra do Garças/MT. Image: The authors.

Figure 3 shows the distribution of HIV/AIDS cases in Nova Xavantina according to the main age groups affected. It is observed that the age group of 2 to 4 years had 2 cases, from 15 to 19 years had 8 cases, 20 to 34 years 43 cases, 35 to 49 years 34 cases, 50 to 64 years 8 cases, 65 to 79 years 2 cases. This age distribution shows the greater vulnerability of young adults and adults of economically active age, possibly reflecting factors such as greater sexual activity, multiple partners, less use of condoms and lack of continuous access to prevention actions. The presence of cases in the age group of 15 to 19 years also draws attention to the need to intensify public policies aimed at sex education in basic education and access to preventive methods among adolescents.

Figure 3

Distribution of HIV/AIDS cases by age group



Source: Data: provided by the Regional Health of Barra do Garças/MT. Image: The authors.

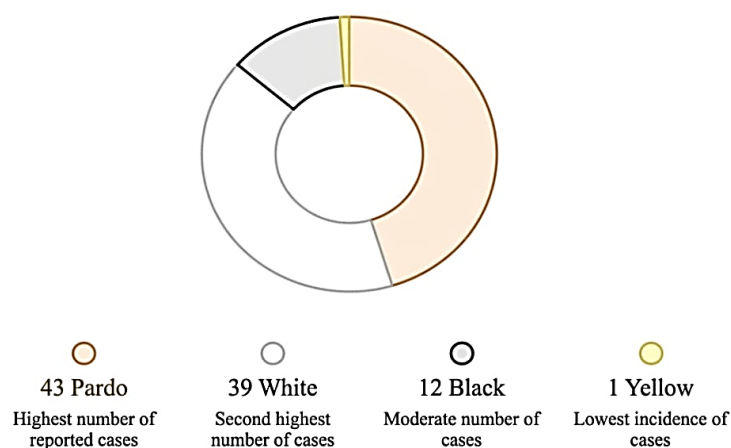
According to records provided by the Regional Health Department of Barra do Garças, between 2009 and 2025, two cases of HIV/AIDS in children were reported. Specifically, there was one case registered in 2010 and another in 2019, children aged 1 to 4 years (figure 3).

The distribution of HIV/AIDS cases by race (figure 4) in the municipality of Nova Xavantina reveals a predominance of people who self-declare themselves brown and white, according to data provided by the Regional Health Department. The brown breed has the highest number of reported cases, totaling 43 records. Next are individuals who identify themselves as white, with 39 cases. Among the black population, 12 cases were registered. The lowest incidence was observed among people of the yellow race, with only 1 case reported.

Figure 4

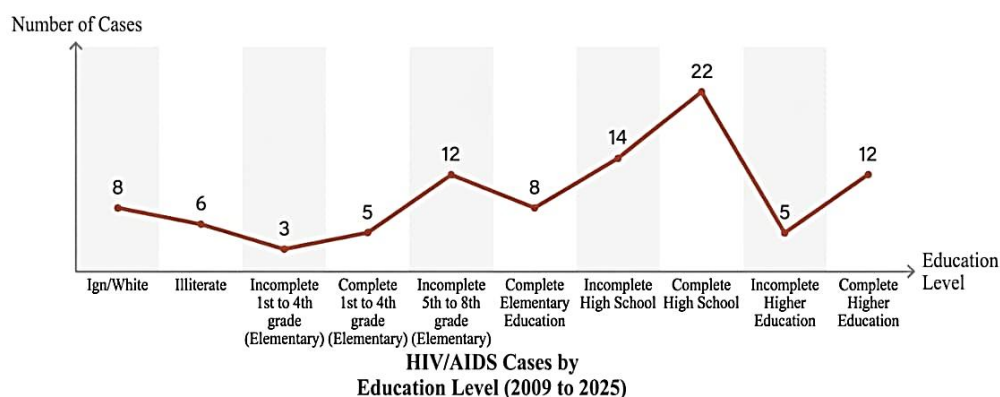
Distribution of HIV/AIDS cases by race

Distribution of HIV/AIDS Cases by Race in Nova Xavantina (cases)



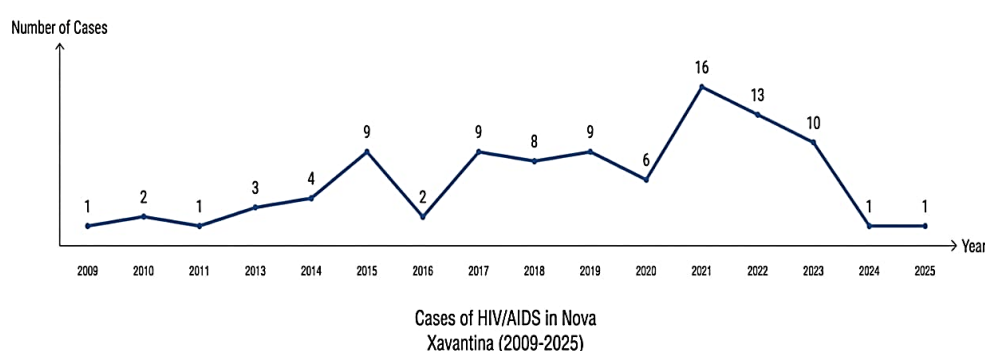
Source: Data: provided by the Regional Health of Barra do Garças/MT. Image: The authors.

The lack of schooling affects a lot, as most of the time there is no education, information, correct literacy, and thus hinders access to HIV, means of transmission, prevention disseminated by social media. Regardless of education, everyone is subject to the disease, however, those who have more access to and understanding of information, can protect themselves more and thus can avoid new transmission. Figure 5 below shows the number of cases by level of education in Nova Xavantina - MT.

Figure 5*HIV/AIDS cases by schooling*

Source: Data: provided by the Regional Health of Barra do Garças/MT. Image: The authors.

Between 2017 and 2021, the numbers fluctuated, remaining at levels of 8 cases in 2018, 9 in 2019 and 6 in 2020. The peak of notifications occurred in 2021, with 16 cases registered, which represents the highest value in the period analyzed. After this peak, there was a downward trend: 13 cases in 2022, 10 in 2023, only 1 case recorded in 2024, and in 2025 (May 2025) only 1 case was reported, respectively (figure 6).

Figure 6*HIV/AIDS cases in Nova Xavantina from 2009-2025*

Source: Data: provided by the Regional Health of Barra do Garças/MT. Image: The authors.

In the survey carried out based on data provided by the Regional Health Department of Barra do Garças – MT, a municipality located approximately 148.9 km from Nova Xavantina – MT, it was observed that only 95 cases of HIV/AIDS were reported in the period from 2009 to

2025. Although this number is considered low in relation to the estimated population of the municipality, which is around 25,915 inhabitants (IBGE, 2025), this data raises questions about the real scope of notification and the supply of antiretroviral drugs. Currently, with the implementation of the Specialized Assistance Service (SAE) and the Testing and Counseling Center (CTA), there has been an expansion in the test collection points, which could, theoretically, reflect in greater detection of cases.

Despite the low number of notifications, the supply of medicines is still limited, with only one vial per month being made available per patient, as informed by local professionals. This practice has generated concern, since any delays in the replenishment of the municipal stock can compromise the continuity of treatment. Considering that the Regional serves several municipalities, the need for proportional distribution is understood, however, it is suggested to evaluate the possibility of an extended release for patients with a history of proven adherence, as is the case of individuals with a condition of undetectable viral load. Such a measure could contribute to the optimization of logistics and the well-being of users, by reducing the frequency of trips to pick up medicines.

The analysis of HIV/AIDS epidemiological data for the municipality of Nova Xavantina, in the period from 2009 to 2025, shows a scenario that partially dialogues with the national pattern, although it presents important particularities related to the regional, demographic, and historical context of organization of local health services. In Brazil, a total of 46,495 new cases of HIV were observed in 2023, with a predominance of males (70.7%) and a higher concentration in the age group of 20 to 29 years, representing 37.1% of notifications (BRASIL, 2024b). Local data follow this trend: most notifications were recorded among men and young adults, especially individuals of economically active age. This convergence suggests that behavioral, social, and cultural factors that influence the national epidemic are also present in the municipal context.

However, when the magnitude of the cases is observed, a discrepancy between the number of local records (95 cases in the period analyzed) and the national pattern becomes evident. Considering the estimated population of Nova Xavantina, the volume of notifications seems relatively low, which indicates probable underdiagnosis or underreporting over the years. The fact that the Specialized Care Service (SAE/CTA) was only implemented in 2023 reinforces this interpretation, since limited access to testing, counseling, and specialized follow-up may have restricted the identification of cases during previous periods. In municipalities in the interior, the absence of structured services usually has a direct impact on epidemiological surveillance, making it difficult to detect early and longitudinally monitor people living with HIV/AIDS (SOUZA et al, 2013).

Another relevant aspect is the racial distribution of notifications. Nationally, the black and brown populations account for more than 60% of recent notifications (BRASIL, 2024b), while in Nova Xavantina cases predominate among self-declared brown and black individuals with 55%, white with 49%. This difference, although partially explained by the local demographic composition, may also reflect social inequalities and variations in access to health services. Inland regions often have additional barriers related to stigma, lack of information, and difficulty in traveling, elements that can interfere with the search for diagnosis and follow-up (SOUZA et al, 2013).

The diversity of exposure categories observed in the municipality, including heterosexuals, homosexuals, bisexuals, and cases of vertical transmission, shows that the infection is not concentrated in a single group, but is distributed among different population segments. This characteristic reinforces the need for broad, integrated, and continuous prevention actions, in line with national recommendations for the promotion of sexual and reproductive health. The presence of cases in children and adolescents, although a minority, points to specific vulnerabilities related to prenatal care, gestational follow-up and sex education in schools (CAMPOS et al, 2013).

The implementation of the SAE/CTA in 2023 is a milestone and a fundamental differential for the municipality, allowing to expand diagnostic coverage, decentralize the provision of care, strengthen prevention actions and ensure savings with travel in the municipality. Since its opening, the service has carried out rapid testing, reception, distribution of prevention supplies, clinical follow-up and educational actions in schools, universities and public spaces. These initiatives dialogue directly with national strategies, which emphasize the importance of early diagnosis, expansion of testing, and continuous treatment as the main means of controlling the epidemic. In addition, the historic drop in AIDS mortality in the country in 2023, reaching 3.9 deaths per 100 thousand inhabitants, the lowest rate since 2013 (BRASIL, 2024b), demonstrates the effectiveness of sustained comprehensive care policies and access to antiretrovirals.

The supply of medicines in limited quantities (one vial per patient per month) still poses risks to the continuity of treatment, especially in a region where delays in distribution or logistical difficulties can compromise adherence. In addition, cultural factors and the stigma associated with sexually transmitted infections can restrict the spontaneous search for testing, making it essential to maintain community awareness, continuing education, and confronting prejudice actions (DIAS et al, 2021).

In summary, the data analyzed indicate that the reality of Nova Xavantina follows part of the national epidemiological trends, but presents specificities related to the structure of the services, the countryside context and the local dynamics of access to health. The continuous strengthening of the NCS/CTA, associated with the expansion of prevention strategies, active epidemiological surveillance, and integration with primary care, is essential to ensure early diagnosis, timely treatment, and reduction of new infections (MELO et al, 2018). Based on this, it is recommended that, in the coming years, indicators such as adherence to treatment, average viral load of the population served, evolution of notifications and changes in the sociodemographic profile of cases be evaluated, in order to allow a consistent assessment of the impact of the service on the dynamics of HIV/AIDS in the municipality.

Despite these obstacles, it is necessary to recognize the work performed by SAE/CTA professionals in the municipality. The performance has been efficient and comprehensive, including laboratory tests, rapid tests, viral load monitoring and CD4/CD8 lymphocyte count, in addition to the regular distribution of medicines and health education actions. With the presence of an infectious disease specialist and adequate laboratory structure, Nova Xavantina was able to reduce the dependence on neighboring municipalities for the care of people living with HIV/AIDS, which represents an advance both in the field of public health and in the management of local resources.

6 CONCLUSION

The data collected at the Testing and Counseling Center (CTA) of Nova Xavantina-MT reinforce the importance of considering sexual orientation and gender identity in the formulation of prevention, diagnosis and treatment strategies. The numbers point to disparities that cannot be ignored and require managers, health professionals and civil society to engage in the construction of inclusive and humanized practices.

Another fundamental point identified was the need to expand the financing and sustainability of HIV/AIDS actions, since both the contribution of national and international resources has been shown to be vulnerable to political and economic oscillations. The judicialization of health, although it represents a legitimate mechanism for guaranteeing rights, also has relevant budgetary impacts, requiring planning and coordination between government spheres.

Therefore, it is concluded that facing the challenges of HIV in the LGBTQIA+ population implies recognizing the centrality of the fight against stigma and discrimination, strengthening the SUS as a space for welcoming and promoting equity, and expanding investments in

research, prevention, and treatment. The effectiveness of the response to HIV is not restricted to the biomedical dimension, but depends on the construction of a more just, inclusive and supportive society, in which diversity is respected and valued.

LIST OF ACRONYMS AND ABBREVIATIONS

AIDS – Acquired Immunodeficiency Syndrome
 CCR5 – C-C chemokine receptor, used by HIV for cell entry
 CD4 – Glycoprotein present on the surface of helper T lymphocytes
 CD4+ – CD4-expressing helper T lymphocytes
 CONASS – National Council of Health Secretaries
 CTA – Testing and Counseling Center
 CXCR4 – CXC chemokine receptor, used by HIV for cell entry
 GLS – Gays, Lesbians and Sympathizers
 GM/MS – Office of the Minister of the Ministry of Health
 HIV – Human Immunodeficiency Virus
 IBGE – Brazilian Institute of Geography and Statistics
 STI – Sexually Transmitted Infection
 STIs – Sexually Transmitted Infections
 LGBT – Lesbian, Gay, Bisexual and Transgender
 LGBTQIA+ – Lesbian, Gay, Bisexual, Transgender, Queer, Intersex, Asexual and other identities
 MT – State of Mato Grosso
 PAS – Annual Health Program
 PEPFAR – President's Emergency Plan for AIDS Relief
 PVVS – Variable Health Surveillance Floor
 RAG – Annual Management Report
 RNA – Ribonucleic acid
 RQPC – Quarterly Accountability Report
 SAE – Specialized Care Service
 SIV – Simian Immunodeficiency Virus
 SUS – Unified Health System
 UNAIDS – Joint United Nations Programme on HIV/AIDS

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PUBLIC POLICIES TO PROMOTE CULTURE AND THE ALLOCATION OF RESOURCES TO THE CREATIVE ECONOMY SECTOR IN THE MUNICIPALITY OF CÁCERES/MT

POLÍTICAS PÚBLICAS DE FOMENTO À CULTURA E A DESTINAÇÃO DE RECURSOS AO SETOR DE ECONOMIA CRIATIVA NO MUNICÍPIO DE CÁCERES/MT

POLÍTICAS PÚBLICAS PARA PROMOVER LA CULTURA Y LA ASIGNACIÓN DE RECURSOS AL SECTOR DE LA ECONOMÍA CREATIVA EN EL MUNICIPIO DE CÁCERES/MT



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ABSTRACT

This study aimed to analyze the impacts of resource allocation by public policies promoting culture on the creative economy sector in the municipality of Cáceres/MT, focusing on the Aldir Blanc Law, the Paulo Gustavo Law, and the Aldir Blanc National Policy (PNAB). The research used a qualitative and quantitative approach, through documentary analysis of official data provided by the Ministry of Culture, the Official Gazette of the Municipalities of the State of Mato Grosso, and the Transparency Portal of the Municipality of Cáceres. The work presents an analysis of the distribution and effectiveness of the use of resources at the state level, with a local analytical focus on the municipality of Cáceres/MT, illustrating how these policies were operationalized at the local level. The results indicate that these policies had a significant impact on the execution of the local public budget and contributed to the maintenance and strengthening of creative enterprises, despite the challenges faced in their implementation and adaptation to local realities. It is concluded that public funding for culture presents strategic potential for strengthening the creative economy, and the continuity and improvement of these policies are necessary to expand their positive impacts.

Keywords: Creative Economy. Public Policies. Aldir Blanc Law. Paulo Gustavo Law. PNAB.

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RESUMO

O presente estudo teve como objetivo analisar os impactos das destinações de recursos pelas políticas públicas de fomento à cultura para o setor de economia criativa no contexto do município de Cáceres/MT, com foco nas Leis Aldir Blanc, Paulo Gustavo e Política Nacional Aldir Blanc (PNAB). A pesquisa utilizou abordagem qualitativa e quantitativa, por meio de análise documental de dados oficiais disponibilizados pelo Ministério da Cultura, pelo Diário Oficial dos Municípios do Estado de Mato Grosso e Portal da Transparência do Município de Cáceres. O trabalho apresenta uma análise da distribuição e da efetividade da utilização dos recursos em âmbito estadual, com um recorte analítico local no município de Cáceres/MT, ilustrando como essas políticas foram operacionalizadas em nível local. Os resultados indicam que essas políticas tiveram impacto relevante na execução do orçamento público local e contribuíram para a manutenção e o fortalecimento de empreendimentos criativos, apesar dos desafios enfrentados na execução e adaptação às realidades locais. Conclui-se que o fomento público à cultura apresenta potencial estratégico para o fortalecimento da economia criativa, sendo necessária a continuidade e o aprimoramento dessas políticas para ampliar seus impactos positivos.

Palavras-chave: Economia Criativa. Políticas Públicas. Lei Aldir Blanc. Lei Paulo Gustavo. PNAB.

RESUMEN

Este estudio tuvo como objetivo analizar los impactos de la asignación de recursos por parte de las políticas públicas de promoción cultural en el sector de la economía creativa del municipio de Cáceres/MT, centrándose en la Ley Aldir Blanc, la Ley Paulo Gustavo y la Política Nacional Aldir Blanc (PNAB). La investigación empleó un enfoque cualitativo y cuantitativo, mediante el análisis documental de datos oficiales proporcionados por el Ministerio de Cultura, el Boletín Oficial de los Municipios del Estado de Mato Grosso y el Portal de Transparencia del Municipio de Cáceres. El trabajo presenta un análisis de la distribución y efectividad del uso de recursos a nivel estatal, con un enfoque analítico local en el municipio de Cáceres/MT, ilustrando cómo se operacionalizaron estas políticas a nivel local. Los resultados indican que estas políticas tuvieron un impacto significativo en la ejecución del presupuesto público local y contribuyeron al mantenimiento y fortalecimiento de las empresas creativas, a pesar de los desafíos que enfrentaron en su implementación y adaptación a las realidades locales. Se concluye que el financiamiento público para la cultura presenta un potencial estratégico para fortalecer la economía creativa, y la continuidad y mejora de estas políticas son necesarias para ampliar sus impactos positivos.

Palabras clave: Economía Creativa. Políticas Públicas. Derecho Aldir Blanc. Derecho Paulo Gustavo. PNAB.

1 INTRODUCTION

The creative economy has been consolidated, in recent decades, as one of the main vectors of economic, social and cultural development in several countries, including Brazil. This field can be defined as the set of activities related to the creation, production, distribution, circulation, consumption, and enjoyment of goods and services whose productive basis resides essentially in the symbolic dimension, creativity, knowledge, and human talent — individual or collective — as the main inputs for the generation of added value (Brasil, 2022; UNCTAD, 2010).

The appreciation of cultural diversity, the promotion of social inclusion and the stimulation of innovation have transformed the creative economy into a strategic component of contemporary public policies, elevating culture to the condition of a central asset for sustainable development. According to UNESCO (2024), the cultural and creative sector is one of the most dynamic in the global economy, contributing about 6.1% of the world's Gross Domestic Product (GDP), moving approximately US\$ 2.25 billion annually and generating almost 30 million jobs, especially young people between 15 and 29 years old — surpassing other sectors in generating opportunities for this age group.

In Brazil, the field of creative economy has gained relevance, especially in regions with expressive cultural richness and natural diversity, as is the case of the state of Mato Grosso. According to data from the Brazilian Micro and Small Business Support Service (Sebrae, 2025), there was a significant increase in the creation of enterprises linked to the creative economy. As an example, the capital Cuiabá showed a 35% growth in the number of creative businesses in the first quarter of 2024, jumping from 121 to 164 registered enterprises.

On the national scene, there has been an important advance in the formulation of public policies aimed at culture and the creative economy, with emphasis on the Aldir Blanc Law (Complementary Law No. 14,017/2020), the Paulo Gustavo Law (Complementary Law No. 195/2022) and the Aldir Blanc National Policy for the Promotion of Culture (PNAB), instituted by Complementary Law No. 14,399/2022. These initiatives, initially of an emergency nature, were later institutionalized as structuring policies and played a key role in strengthening the cultural sector during and after the Covid-19 pandemic, ensuring the continuity of cultural activities and the appreciation of creative entrepreneurs throughout the country.

Given the relevance of these policies, it is necessary to deepen the analysis of how public resources destined to the cultural sector were applied and what challenges were faced in their operationalization, especially at the state and municipal levels. Such research allows us to evaluate the effectiveness of public funding and its ability to promote the strengthening of the creative economy and the appreciation of cultural agents in different territories.

In this context, this study proposed to answer the following research question: what are the impacts of the allocation of resources from public policies to promote culture for the creative economy sector in the context of the municipality of Cáceres/MT?

To this end, the general objective was to analyze the impacts of the allocation of resources by public policies to promote culture for the creative economy sector in the context of the municipality of Cáceres/MT. Among the public policies to promote culture, this study selected as the object of analysis the Aldir Blanc Laws, Paulo Gustavo Law and the Aldir Blanc National Policy (PNAB).

Thus, it was sought to understand how public policies to promote culture were implemented in different federative spheres and, from the sample of the municipality of Cáceres, to evaluate their consequences for the strengthening of the local creative economy. The relevance of this study lies in its contribution to the improvement of cultural policies, by offering subsidies for the formulation of more effective future actions, in addition to enriching the debate on the strategic role of the creative economy in territorial development, evidencing its potential for social inclusion, income generation and economic dynamism.

2 THEORETICAL FRAMEWORK

2.1 CREATIVE ECONOMY: HISTORICAL AND CONCEPTUAL ASPECTS

For the United Nations (UN), the Creative Economy (CE) comprises a set of economic activities based on creativity, knowledge and cultural expression, involving the cycle of creation, production and distribution of goods and services that use creativity and skill as main inputs, with the potential to generate employment, income and sustainable economic growth. This evolving concept is based on creative assets capable of driving economic growth and development, and is considered an important driver for sustainable development, promoting social inclusion and valuing cultural diversity (UNCTAD, 2010).

The creative economy is a relatively recent concept, whose origin is strongly linked to the evolution of the notions of creative and cultural industries. The term began to take shape in the 1990s, driven by economic, technological, and social transformations that highlighted the central role of creativity, knowledge, and culture as engines of economic and social development (Gabriel; Souza; Fumagalli, 2019).

A key early milestone of the creative economy was the *Creative Nation: Commonwealth Cultural Policy report*, released by the Australian government in 1994. This document highlighted the importance of culture for national identity and for the economy, proposing public policies that valued cultural and artistic production as a strategy for economic development, in

addition to emphasizing that creativity would be essential for the country's adaptation to new economic demands and for competitive insertion in the global scenario (*Australian Government, 1994*).

In the United Kingdom, in 1997, the government led by Tony Blair created a multisectoral task force to analyze the economic potential of creative activities, resulting in the *Creative Industries: Mapping Document*. This document identified thirteen sectors with the greatest economic potential, consolidating the expression "creative industries" and establishing an integrated agenda between government, private sector and cultural creators. This initiative has become a global reference in public policies for the creative economy (DCMS, 1998).

From the 2000s onwards, the creative economy became a central theme in international conferences and reports by multilateral organizations, especially the United Nations (UN), through UNCTAD (United Nations Conference on Trade and Development) and UNESCO. In 2010, UNCTAD's *Creative Economy Report* consolidated the concept, highlighting that, if well nurtured, the creative economy can be a significant source of economic growth, job creation, innovation and trade, as well as promoting social inclusion, cultural diversity and sustainable human development (UNCTAD, 2010).

In Brazil, discussions on the creative economy gained strength from 2004 onwards, with the recognition of the sector as strategic for economic diversification, job creation and promotion of national culture. The country began to invest in public policies and research that highlight the importance of the creative economy, which moves billions of reais and formally employs hundreds of thousands of people (Brasil, 2011).

According to UNCTAD (2010), the main categories of the creative economy include: natural and cultural heritage (museums, archaeological sites, cultural landscapes, natural heritage); shows and celebrations (performing arts, festivals, cultural fairs); visual and plastic arts (handicrafts, painting, sculpture, photography); books and periodicals (books, newspapers, magazines, physical and digital libraries); audiovisual and interactive media (cinema, television, radio, internet, *podcasts*, video games, production and distribution of audiovisual content); *design* and creative services (*graphic design*, fashion, interiors, architecture, advertising).

In Brazil, sectors such as audiovisual production (cinema, *streaming*, advertising), digital games, music and cultural festivals, digital *marketing* and content production, and literature and independent publishers are highlights of the creative economy, generating jobs, innovation, and economic growth (Sebrae, 2025).

2.2 PUBLIC POLICIES TO PROMOTE CULTURE AND ALLOCATE RESOURCES TO THE CREATIVE ECONOMY IN BRAZIL

Public policies to encourage culture have proven to be fundamental for the development of the Brazilian creative economy. In the same sense, UNESCO reinforces the importance of including culture and the creative economy in countries' development plans, in addition to encouraging financing actions aimed at the creative industries as strategies to promote inclusive and sustainable growth (UNESCO, 2021). This conception recognizes culture as a strategic axis for development, valuing the symbolic and creative potential of the territories and promoting the generation of employment, income and the strengthening of local identities.

Although the concept of creative economy has broadened the understanding of the role of culture in social and economic development, the main focus of public policies aimed at culture in Brazil has historically been directed to the creation of financing mechanisms that would enable cultural activities to be carried out, especially those with difficulties in accessing resources through traditional channels. such as bank loans, private sponsorships, own or third-party capital, which often prove inaccessible to most independent cultural entrepreneurs (Ipea, 2021).

According to Rubim (2011) *apud* Calabre (2009), the enactment of Law No. 7,505/1986, known as the Sarney Law, represented a milestone in the institutionalization of cultural funding in Brazil, by introducing tax incentives to stimulate private investments in cultural projects. This legislation was succeeded by Law No. 8,313/1991, the Rouanet Law, which consolidated the National Program for Cultural Support (PRONAC), establishing mechanisms such as the National Culture Fund (FNC) and tax incentives via patronage.

These initiatives highlight the focus of Brazilian cultural policies on creating financing instruments that would enable cultural activities to be carried out, especially in view of the limitations of access to resources. In 2020, this legislation was officially renamed the Culture Incentive Law, remaining the main mechanism for tax incentives for culture in the country (Ribeiro *et al.*, 2023).

During the Covid-19 pandemic, the fragility of the cultural sector highlighted the need for more direct emergency actions. In this context, the Aldir Blanc Law (Law No. 14,017/2020) was sanctioned, which allocated R\$ 3 billion from the Union to the states, the Federal District and municipalities, with the aim of ensuring the survival of the cultural sector. The application of the resources was regulated by Ordinance No. 62/2020, which defined the transfer criteria, based on the estimated population of the municipalities (according to the IBGE) and the coefficients of the State Participation Funds (FPE) and Municipalities (FPM) (Brasil, 2020a; Brasil, 2020b).

In continuity with the emergency support process, the Paulo Gustavo Law (Complementary Law No. 195/2022) was created, which released around R\$ 3.86 billion for the cultural sector, with a strong emphasis on audiovisual production. This legislation reinforced the role of the State in the reconstruction of the cultural sector, expanding access to resources in a more direct and simplified way (Brasil, 2022).

The consolidation of this movement took place with the New Aldir Blanc Law (Law No. 14,399/2022), which institutes the Aldir Blanc National Policy for the Promotion of Culture (PNAB). Unlike the first version, which was of an emergency nature, the PNAB establishes a permanent development policy for five years, with annual transfers planned until 2027, totaling R\$ 3 billion per year. The new legislation proposes a federative cultural pact, strengthening state and municipal culture systems and valuing social participation (Brasil, 2022b).

In this context, the growing importance of development policies as instruments of local development is observed, especially in smaller municipalities, where cultural resources can represent a significant boost for creative enterprises, which have a growing role in the generation of income, employment and innovation. Therefore, for this growth to be maintained, it is essential to continuously support public policies that encourage entrepreneurship, innovation, and the appreciation of creative talents, promoting a favorable environment for micro and small companies in the sector (Tenório Vieira, 2023; Sebrae, 2025).

3 METHODOLOGY

This study is characterized as a qualitative and quantitative research, of descriptive character, with a focus on documentary analysis. The main objective was to examine the impacts of the allocation of public resources applied in the cultural sector through the main policies to promote the creative economy in Brazil, with an analytical focus in the state of Mato Grosso and sampling in the municipality of Cáceres.

The official documents made available by the Ministry of Culture were used as primary sources of data, notably the data panels of the Aldir Blanc and Paulo Gustavo Laws and the Aldir Blanc National Policy (PNAB). In addition, public documents accessed in the Official Gazettes of the Municipalities of the State of Mato Grosso and the Transparency Portal of the Municipality of Cáceres were analyzed, including municipal laws, regulatory decrees, ordinances, public notices and budget and financial execution reports related to the application of resources.

Data collection took place between April and May 2025, covering the period from 2020 to 2024 — corresponding to the implementation cycle of the three policies analyzed. The

analysis was structured in three stages:

- a) First stage: survey of resources destined to states and municipalities, focusing on the distribution and execution criteria within the state of Mato Grosso.
- b) Second stage: analysis of the budgetary and financial impacts of the allocation of public resources from the Development Policies in the municipality of Cáceres.
- c) Third stage: analysis of three selection processes carried out by the municipality of Cáceres (one referring to each policy: Aldir Blanc Law, Paulo Gustavo Law and PNAB), focusing on identifying the profiles of the cultural enterprises contemplated.

The data were organized in tables, allowing the identification of transfer patterns, execution rates and beneficiary profiles, and are presented in the next section.

4 RESULTS AND DISCUSSIONS

4.1 GLOBAL ANALYSIS OF THE ALLOCATION OF RESOURCES BY POLICIES FOR THE PROMOTION OF CULTURE IN THE STATE OF MATO GROSSO

4.1.1 Law No. 14,017/2020 (Aldir Blanc Law)

The enactment of Law No. 14,017, of June 29, 2020, known as the Aldir Blanc Law, established a milestone in Brazilian cultural public policy by instituting an emergency aid of R\$ 3 billion for the cultural sector that was heavily impacted by the COVID-19 pandemic. The operationalization of the distribution of resources was regulated by Decree No. 10,464/2020, which established the criteria for transfer in a single installment to the federative entities.

The distribution of the R\$ 3 billion of the Aldir Blanc Law in the 2020 fiscal year among the Brazilian states used the criteria established by the legislation itself, which mainly consider population factors, in addition to aspects related to social vulnerability and the ability to execute cultural policies.

Although states with smaller populations and economic dimensions, especially in the North and Midwest regions, received more modest shares, the policy sought to ensure national coverage. In this context, the state of Mato Grosso was awarded R\$ 30,016,809.05, equivalent to 1.00% of the total transferred. This amount represents an important reinforcement of local cultural policies, considering the cultural diversity of the state, marked by indigenous, Afro-descendant and traditional expressions, in addition to its relationship with the Cerrado, Pantanal and Amazon biomes.

Among the 141 municipalities in Mato Grosso, Cuiabá concentrated most of the resources, with R\$ 3,900,000.00, corresponding to 12.99% of the state total. It was followed

by Várzea Grande (6.00%) and Rondonópolis (5.00%), reflecting, in part, the centralization in municipalities of larger size and economic and population relevance.

The municipality of Cáceres received R\$ 640,900.00, representing 2.14% of the state amount, being among the 10 municipalities with the highest volume of transfers. This amount is considerably higher than the state average per municipality, estimated at approximately R\$ 212,654.60, indicating an above-average allocation.

The comparative analysis suggests that there is a correlation between the values transferred and variables such as the number of inhabitants, Gross Domestic Product (GDP) and Municipal Human Development Index (MHDI). However, according to the criteria established by the Aldir Blanc Law, the distribution of resources was based mainly on the number of inhabitants – according to IBGE estimates – in addition to the apportionment criteria of the State Participation Fund (FPE) and the Municipal Participation Fund (FPM).

Regarding the effectiveness of the use of resources, it was observed that most municipalities were able to fully apply the amounts received, with emphasis on 100% execution in locations such as Apiacás, Alta Floresta, Alto Araguaia, and several others. However, some municipalities had a residual balance or even negative execution, as is the case of Pedra Preta, Santa Terezinha and São José do Xingu, where the balances exceeded the amounts initially transferred, indicating possible inconsistencies in the execution or subsequent accounting adjustments.

Although most municipalities have achieved a full or satisfactory execution of the resources, evidencing commitment to the cultural public policy, the heterogeneity in effectiveness points to the need for improvement in technical training and in the monitoring of cultural management, especially in smaller municipalities or with less administrative structure, whose data indicated the absence of allocation of the resources received to local creative enterprises.

4.1.2 Complementary Law No. 195/2022 (Paulo Gustavo Law)

The Paulo Gustavo Law (Complementary Law No. 195/2022) represents the largest direct investment ever made in the cultural sector in Brazil, allocating R\$ 3.862 billion for the execution of cultural actions and projects throughout the national territory. This development policy, administered by the Ministry of Culture and aimed at cultural professionals, allowed access to resources through public notices, public calls, awards, acquisition of goods and services or other forms of simplified public selection (Brasil, 2024).

Although it was sanctioned in 2022, there are still resources that have not been fully used

by states and municipalities. Many have already received the transfers, but not all have completed the application of the amounts in the local Creative Economy sector.

According to the Data Panel made available by the Ministry of Culture, it is possible to monitor the progress of the financial execution and verify that a significant portion of the resources are still in the execution or planning phase, with deadlines that extend until the year 2025.

The distribution of resources from Complementary Law No. 195/2022 (Paulo Gustavo Law) in the state of Mato Grosso, which totaled R\$ 36,006,534.90, plus financial income, observed the population criterion established by Decree No. 11,525/2023. This methodology aimed to ensure distributive justice in access to cultural promotion among the 141 municipalities of Mato Grosso.

It is observed that most of the municipalities in Mato Grosso have almost fully executed the resources received through the Paulo Gustavo Law. Several municipalities, such as Acorizal, Alto Araguaia, Alto Garças, Arenápolis, Brasnorte, Campinápolis, Campos de Júlio, Cana Brava do Norte, Colíder, Confresa, General Carneiro, Jaciara, Jangada, Lambari D'Oeste, Lucas do Rio Verde, Marcelândia, Nobres, Nossa Senhora do Livramento, Nova Canarana do Norte, Nova Monte Verde, Nova Mutum, among others, recorded an application rate of 100% of the amounts received plus the income values, evidencing an efficient management and commitment to the execution of resources destined to the cultural sector.

In the specific case of Cáceres, 96.5% of the resources from the aforementioned Law were executed, which indicates the existence of a remaining cash balance from this public policy. In view of this scenario, it is important that the Municipal Department of Culture adopts the necessary measures so that such amounts are properly allocated to local cultural promotion, ensuring the full realization of the objectives of the Law and expanding the benefits for the municipality's culture makers.

On the other hand, some municipalities presented significant balances or execution percentages lower than 80%, such as Alto Taquari (55%), Cláudia (53%), Juara (51%) and Nova Lacerda (50%). This picture reveals a partial execution of resources, which may reflect administrative difficulties, bureaucratic obstacles or strategic issues related to the management and use of public funds.

In addition, it was found that in certain municipalities the balances remain totally or partially unused, as occurs in Alto Paraguai, Conquista D'Oeste, Denise, Gaúcha do Norte, Indiavaí, Itiquira, Jauru and Nova Bandeirante, which did not present clear information about the final destination of the resources.

The general panorama shows a good capacity for execution on the part of most municipalities in the State of Mato Grosso, reinforcing the relevance of structuring public policies in the cultural sector and the effectiveness of the decentralization of resources promoted by the Paulo Gustavo Law. However, the differences in effectiveness analyzed suggest the need for complementary studies that seek to understand, in a more in-depth way, the factors that hindered the full execution of resources in certain municipalities, with a view to improving administrative practices and optimizing the impact of cultural policies in the state territory.

4.1.3 Complementary Law No. 14,399/2022 (Aldir Blanc National Policy)

Complementary Law No. 14,399, of July 8, 2022, establishes the Aldir Blanc National Policy for the Promotion of Culture (PNAB) as a permanent public policy, ensuring annual transfers of resources from the Union to States, the Federal District, and Municipalities until the year 2027. The PNAB is a structuring response to the weaknesses of the cultural sector, especially evidenced during the COVID-19 pandemic, and is consolidated as a legal framework for the continued promotion of culture in Brazil, reinforcing the role of the State in promoting cultural diversity and strengthening local creative economies.

Cycle 1 of the PNAB corresponds to the first effective transfer made by the Union in 2023 and 2024, operated by the TransfereGov Platform, under the monitoring of the Ministry of Culture. In this cycle, the subnational entities presented their action plans containing goals, priority cultural actions and forecast for the use of resources, which, once approved, were credited to specific accounts of the FEC (State or Municipal Fund for Culture).

The allocation of values obeys the federative logic, respecting local autonomies, and seeks to reduce inequalities in access to cultural resources, fostering the decentralization and regionalization of public policies in the sector.

The State of Mato Grosso, the object of interest in this study, received approximately R\$ 26 million, corresponding to 1.7% of the national total. However, its application effectiveness is still considered low, with only 4.74% of the resources executed so far. This data suggests the existence of operational bottlenecks in the management of cultural resources in the state, which can compromise the effectiveness of public policy and delay the achievement of benefits to local culture makers. The situation is even more relevant when considering the rich cultural diversity and territorial extension of the state, factors that would potentially require a more agile and capillary management.

In general, there is a significant variation between the total resources received and the percentage of budget execution. In many municipalities, the percentage of execution was equal

to 0%, signaling a total absence of application of the amounts, while others exceeded the amount initially received, resulting in percentages above 100%, which may indicate the full use of resources plus their income.

In this context, Cáceres stands out negatively: although he received a significant amount of R\$ 626,128.06 (plus income), he managed to apply only 54.88% of the resources, maintaining a considerable balance in the account. This performance highlights administrative challenges and the need to strengthen local cultural policies, especially in a municipality with recognized cultural and tourist potential in the Pantanal.

Thus, the general panorama and the specific case of Cáceres reinforce the importance of training and planning in cultural management, aiming to ensure that future policies achieve their objectives fully and efficiently.

4.2 ANALYSIS OF THE BUDGETARY AND FINANCIAL IMPACTS OF POLICIES TO PROMOTE CULTURE IN THE MUNICIPALITY OF CÁCERES

This section presents the analysis of the budgetary and financial execution of public policies to promote culture in the Municipality of Cáceres-MT, in the period from 2020 to 2024. The approach is structured in three levels: an overview of the execution of the budget of the Secretariat of Tourism and Culture, the specific government function "Culture" and the subfunction "Cultural Diffusion", enabling an integrated understanding of the role and effects of these resources in local public management.

Table 1 presents the budget execution of the Secretariat of Tourism and Culture of Cáceres/MT and the impact of the resources of the Policies for the Promotion of Culture (PFC) on the local budget. Although they represent a relatively modest portion of the overall budget of the Municipal Department of Tourism and Culture, these transfers were fundamental to enable the financial contribution in the subareas most directly related to cultural dissemination.

Table 1

Budget Execution of the Department of Tourism and Culture of Cáceres/MT

Year	Fixed Expenditure	Settled Expense	Appeal Received PFC*	Percentage of Settled Expense
2020	R\$ 10.115.974,12	R\$ 2.768.719,34	R\$ 640.864,00	23,15%
2021	R\$ 8.482.330,49	R\$ 3.538.810,30	R\$ 0,00	0,00%
2022	R\$ 21.599.772,	R\$ 11.899.879,94	R\$ 0,00	0,00%

	02				
2023	R\$ 35.813.802,55	R\$ 15.927.307,85	R\$ 650.849,79		4,09%
2024	R\$ 31.887.689,91	R\$ 14.448.770,02	R\$ 775.139,01		5,36%

*Note: PFC = acronym for Policies for the Promotion of Culture

Source: Survey Data

In general, the expenditure set by the Secretariat is significantly higher than the expenditure settled in all the years analyzed, which shows a tendency to overestimate budget expenditure or low effectiveness of public spending in this area. In 2020, of just over R\$ 10 million fixed, only 27% were effectively settled. The same pattern is repeated in other years, with settlements always below 50% of the fixed.

With regard to resources from federal public policies for the promotion of culture (PFC) — such as the Aldir Blanc Law (2020), the Paulo Gustavo Law (2023) and the PNAB - Cycle 1 (2024) — it is observed that, although important, these amounts represent relatively modest percentages within the Secretariat's overall budget: 2020: 23.15%; 2023: 4,09%; 2024: 5,36%.

This low representativeness occurs because the Secretariat's budget includes not only cultural actions, but also activities involving tourism, which dilutes the perception of the impact of these federal transfers on the total of the portfolio.

On the other hand, when the analysis is specifically directed to budget execution by Culture government function, federal funding transfers become more expressive in relation to settled expenditure, as can be seen in Table 2.

Table 2

Budget Execution by the Government Function Culture

Year	Fixed Expenditure	Settled Expense	Appeal Received PFC*	Percentage of Settled Expense
2020	R\$ 6.827.301,57	R\$ 2.556.426,33	R\$ 640.864,00	25,07%
2021	R\$ 4.351.111,49	R\$ 2.436.036,84	R\$ 0,00	0,00%
2022	R\$ 7.467.678,93	R\$ 3.188.617,11	R\$ 0,00	0,00%
2023	R\$ 14.900.216,89	R\$ 3.212.065,01	R\$ 650.849,79	20,26%
2024	R\$ 13.488.189,91	R\$ 2.913.678,	R\$ 775.139,01	26,60%

*Note: PFC = acronym for Policies for the Promotion of Culture
Source: Survey Data.

In 2020, the resource of the Aldir Blanc Law represented 25.07% of the total paid for Culture, evidencing its importance for the maintenance of the municipality's cultural activities that year. In 2023 and 2024, with the transfers of the Paulo Gustavo and PNAB Laws, this share was also significant: 20.26% and 26.60%, respectively.

However, as in the Secretariat's global view, the Culture function also presents a marked discrepancy between the amounts fixed and those actually settled. For example, in 2023, almost R\$ 15 million in expenses were fixed, but just over R\$ 3.2 million were settled, that is, only 21% of the liquidated value of the forecast.

The analysis of the budget execution of the Cultural Diffusion subfunction reveals an even more interesting and specific scenario in the context of public policies to promote culture in Cáceres-MT, as evidenced in Table 3.

Table 3

Budget Execution by the Subfunction of Government Cultural Diffusion

Year	Fixed Expenditure	Settled Expense	Appeal Received PFC*	Percentage of Settled Expense
2020	R\$ 1.576.152,51	R\$ 900.076,47	R\$ 640.864,00	71,20
2021	R\$ 1.337.511,49	R\$ 117.714,43	R\$ 0,00	0,00%
2022	R\$ 3.993.382,23	R\$ 2.955.673,74	R\$ 0,00	0,00%
2023	R\$ 10.104.216,89	R\$ 2.726.039,30	R\$ 650.849,79	23,88
2024	R\$ 12.446.911,20	R\$ 2.068.796,08	R\$ 775.139,01	37,47

*Note: PFC = acronym for Policies for the Promotion of Culture
Source: Cáceres-MT City Hall

In general, it is observed that the budget execution in this subdivision of the government function is more efficient, with settlement percentages in relation to the fixed value higher than those observed in the Culture function and in the Secretariat as a whole.

In 2020, for example, the Cultural Diffusion subfunction reached an execution of 71.20% of the fixed expenditure, and the resources from the Aldir Blanc Law represented almost the entire amount paid in that year. In the following years, although there are variations, the subfunction maintained relevant percentages of use of PFC resources, such as 23.88% in 2023, with the application of resources from the Paulo Gustavo Law, and 37.47% in 2024, with the implementation of the Aldir Blanc National Policy (PNAB) – Cycle 1.

These data indicate that the receipt of federal resources, analyzed from the perspective of the Cultural Diffusion subfunction, was of great relevance for the performance of the portfolio

as a whole. Thus, the need to strengthen the performance of the Municipal Department of Tourism and Culture is evident, especially with regard to the preparation of adequate planning and the guarantee that the City Hall is able to receive and execute federal resources for cultural promotion.

In this context, the institutionalization of the Aldir Blanc National Policy for the Promotion of Culture (PNAB), through Law No. 15,132/2025, represents a strategic opportunity for the municipality, by ensuring the continuity of federal transfers to the cultural sector (Brasil, 2025). However, for local cultural enterprises to be sustainable in the long term, it is essential that the municipality of Cáceres does not depend exclusively on these resources and develops its own mechanisms to finance cultural dissemination, through investments with municipal resources, in order to ensure greater autonomy, emancipation and strengthen local cultural management. Expanding the execution capacity of the Department of Culture and continuously investing in the area are essential steps to consolidate culture as a vector of economic and social development.

4.3 ANALYSIS OF THE ALLOCATION OF RESOURCES BY POLICIES TO PROMOTE CULTURE IN CREATIVE ECONOMY ENTERPRISES IN THE MUNICIPALITY OF CÁ CERES

For the analysis of the application of public policies to promote culture in the municipality of Cáceres, it was decided to select three public notices as a representative sample of each of the main cultural policies implemented in recent years. The following were considered: a public notice referring to the Provisional Measure of the Aldir Blanc Law (2020), a public notice corresponding to the execution of Complementary Law No. 195/2022 (Paulo Gustavo Law), and a public notice linked to the first cycle of the Aldir Blanc National Policy for the Promotion of Culture (PNAB), instituted by Complementary Law No. 195/2022 and regulated in 2023.

This approach allows a more in-depth reading of the cultural areas prioritized by the municipality and how the federal resources, transferred via PNAB, were operationalized in the local context. From the categorization of the selected proposals, as presented in Table 4, we sought to understand the diversity of artistic languages served, the participation of local cultural agents and the alignment of actions with the guidelines of the national policy for the promotion of culture.

Table 4

Analysis of Public Notice No. 001/2020 of the Aldir Blanc Law

Proponent	Culture Category	Number of Proposals	%
Individual	Music	27	37,50%

Legal Entity	Visual Arts	11	15,28%
	Audio Visual	1	1,39%
	Other	19	26,39%
	Music	6	8,33%
	Visual Arts	1	1,39%
	Audio Visual	6	8,33%
	Other	1	1,39%

Source: Survey Data.

The analysis of Public Notice No. 001/2020, referring to the emergency execution of the Aldir Blanc Law in the municipality of Cáceres (MT), shows the selection of 72 proposals for cultural funding, totaling a transfer of R\$ 496,713.48. It is noteworthy that most of the beneficiaries were individuals, with 58 proposals approved, while 14 were submitted by legal entities, which indicates a significant involvement of artists and individual cultural agents in the city.

With regard to the cultural categories covered, Table 5 shows a significant diversity of artistic languages, with a predominance of the musical segment, which brought together 33 proposals, corresponding to approximately 45.83% of the total. Other areas of emphasis include the visual arts, with 12 proposals; audiovisual, with 7; and literature, with 6 approved proposals. In addition to these, initiatives in the areas of dance, theater, gastronomy and other cultural manifestations were also contemplated, demonstrating the breadth of the promotion actions and the reach of the cultural public policies implemented through this notice.

Table 5

Analysis of Public Notice No. 008/2024 of the Paulo Gustavo Law

Proponent	Category	Number of Proposals	%
Women	Handicrafts	2	60%
	Visual Arts	1	
	Performing art	0	
	Music	1	
	Cultural Manifestation	1	
	Heritage and Culture	2	
	Literature	1	
	Training, training and cultural research.	0	
Men	Handicrafts	0	40%
	Visual Arts	1	
	Performing art	2	
	Music	1	
	Cultural Manifestation	1	
	Heritage and Culture	0	
	Literature	1	
	Training, training and cultural research.	1	

Source: Survey Data.

Public Notice No. 008/2024 included 15 cultural proposals, totaling R\$ 215,046.45 for creative enterprises, with a balanced distribution among various areas of the Creative Economy. Women were responsible for 60% of the proposals, while men represented 40%, highlighting the female participation in segments such as handicrafts and cultural heritage.

The categories contemplated included handicrafts, visual arts, performing arts, music, cultural manifestations, cultural heritage, literature and training, training and cultural research, evidencing the diversity and scope of public development policies in the municipality.

Tables 6 and 7 present the data on the allocation of resources by the Aldir Blanc Law – Cycle 01 PNAB, categorized, respectively, by gender and vacancy reservation.

Table 6

Analysis of Public Notice No. 009/2024-SMTC Aldir Blanc Law – Cycle 01 PNAB by Gender

Proponent	Category	Number of proposals	%
Women	Handicrafts	1	33,33%
	Visual and Audiovisual Arts	1	
	Performing Arts and Diversity	1	
	Music	0	
	Dance	1	
	Cultural Heritage	2	
	Literature	1	
Men	Handicrafts	2	57,14%
	Visual and Audiovisual Arts	2	

	Performing Arts and Diversity	2	
	Music	3	
	Dance	0	
	Cultural Heritage	1	
	Literature	2	
Association	Dance	2	9,53%

Source: Survey Data.

Table 7

Public Notice No. 009/2024-SMTC Aldir Blanc Law – Cycle 01 PNAB by Vacancy Reservation

Quota Vacancy Group	Quantity	%
Black People (black and brown)	9	43%
Wide Competition	11	52%
PCD	1	5%

Source: Survey Data.

The analysis of Public Call Notice No. 009/2024-SMTC (Aldir Blanc Law) referring to the first cycle of the Policy in the municipality of Cáceres, shows the local commitment to the promotion of diversity and democratization of access to public resources. Through the notice, 21 proposals were contemplated, distributed among different artistic categories, such as handicrafts, visual and audiovisual arts, performing art, music, dance, cultural heritage and literature.

Of the total, 7 proposals were authored by women, 12 by men and 2 by associations, reflecting a diversified participation. The transfer was made through the award modality, according to Law No. 14,399/2022, with fixed amounts predominantly of R\$ 10,672.63, intended for the execution of the projects.

The adoption of quotas stands out, promoting affirmative actions: 9 vacancies were allocated to black people (black and brown), 1 to people with disabilities (PCD) and 11 by wide competition. This distribution reinforces the commitment to equity and social inclusion, expanding the reach of cultural public policies to historically underrepresented segments.

Thus, it is observed that the operationalization of the PNAB in Cáceres sought not only to foster local artistic production, but also to strengthen the cultural heritage and value the cultural identity of the municipality.

5 CONCLUSION

This study sought to analyze the impacts of the allocation of resources by public policies to promote culture for the creative economy sector in the context of the municipality of Cáceres/MT. The analysis carried out shows the relevance of public policies to promote culture for the strengthening of the creative economy in Brazil, with emphasis on the state of Mato

Grosso and the municipality of Cáceres. The resources from the Aldir Blanc Law, the Paulo Gustavo Law and the Aldir Blanc National Policy for the Promotion of Culture (PNAB) were essential contributions for the maintenance and encouragement of cultural activities, especially in a scenario marked by the health and economic crisis resulting from the Covid-19 pandemic.

It was observed that, in general, the municipalities of Mato Grosso presented a satisfactory level of execution of resources, reflecting the local commitment to cultural development. However, significant challenges persist that may be related to management, planning and technical training, especially in smaller municipalities, which limits the full use of the potential of these investments.

The municipality of Cáceres stood out positively, configuring itself as an example of good governance and effectiveness in the application of resources, which reinforces the importance of qualified administrative practices for the success of cultural policies, especially due to the concern with the equitable allocation among the various social groups, with reservations of vacancies for affirmative actions and people with disabilities.

The heterogeneity in the application of resources among the municipalities points to the urgent need for complementary policies that promote technical assistance, training and continuous monitoring, ensuring a more efficient and qualified execution of public resources. Such measures would amplify the positive impacts, strengthening the local creative economy and contributing to the diversification and dynamization of the regional economy.

This study contributes to the reflection on the centrality of cultural policies in regional development, emphasizing the importance of continuity, improvement and expansion of these actions. Consolidating culture as the structuring axis of sustainable development and social inclusion strategies in Brazil requires the commitment of public managers and society to promote environments favorable to innovation, collaboration and the appreciation of local talents. The experience of Mato Grosso, especially in the municipality of Cáceres, demonstrates that, with effective management and integrated policies, the creative economy can be a decisive vector for balanced and sustainable territorial development.

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***Galactia glaucescens* KUNTH – FABACEAE (Leguminosae): STATE-OF-THE-ART**

***Galactia glaucescens* KUNTH – FABACEAE (Leguminosae): ESTADO-DA-ARTE**

***Galactia glaucescens* KUNTH – FABACEAE (Leguminosae): ESTADO DEL ARTE**



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ABSTRACT

Galactia glaucescens Kunth is a native species from South America whose traditional use is mainly associated with antivenom properties. Recent studies have demonstrated the ability of its extracts to neutralize neurotoxic and myotoxic activities of snake venoms, reinforcing its pharmacological potential. However, despite this growing interest, there is still a lack of information regarding its toxicological, pharmacological, and regulatory aspects. Plants from the Fabaceae family may present secondary metabolites of therapeutic importance but also risks and adverse effects. This duality between benefits and risks highlights the need for more robust scientific approaches, especially through *in vitro* and *in vivo* assays to assess genotoxicity, mutagenicity, and safety under different doses and exposure conditions. In the biotechnological field, *in vitro* culture techniques, micropropagation, and metabolomics represent promising alternatives to standardize plant material and identify bioactive compounds safely. Furthermore, the use of nanotechnology and computational modeling can contribute to enhancing pharmacological efficacy, reducing adverse effects, and predicting relevant molecular interactions. Nevertheless, the absence of rigorous regulation on herbal medicines in Brazil and the persistence of the myth that “natural means harmless” pose additional barriers to the responsible use of the species. It is concluded that *G. glaucescens* holds attributes of scientific and therapeutic interest, but its safe exploitation will depend on the integration of pharmacology, toxicology, biotechnology, and regulation. Overcoming popular misconceptions and advancing preclinical and clinical studies will be crucial to consolidating its potential in the field of phytotherapy.

Keywords: Biotechnology. *Galactia glaucescens*. Phytotherapy. Toxicity.

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RESUMO

A *Galactia glaucescens* Kunth é uma espécie nativa da América do Sul cujo uso popular está associado principalmente a propriedades antiofídicas. Estudos recentes têm demonstrado a capacidade de seus extratos em neutralizar atividades neurotóxicas e miotóxicas de venenos ofídicos, reforçando seu potencial farmacológico. Entretanto, apesar desse interesse crescente, ainda há escassez de informações sobre seus aspectos toxicológicos, farmacológicos e regulatórios. Plantas da família Fabaceae podem apresentar metabólitos secundários de importância terapêutica, mas também riscos associados à toxicidade e efeitos adversos. Essa dualidade entre benefícios e riscos impõe a necessidade de abordagens científicas mais robustas, especialmente por meio de ensaios *n vitro* e *in vivo* que avaliem genotoxicidade, mutagenicidade e segurança em diferentes doses e condições de exposição. No campo biotecnológico, técnicas de cultivo *in vitro*, micropropagação e metabolômica representam alternativas promissoras para padronizar o material vegetal e identificar compostos bioativos de forma segura. Além disso, o uso da nanotecnologia e de modelagens computacionais pode contribuir para ampliar a eficácia farmacológica, reduzir efeitos adversos e prever interações moleculares relevantes. Contudo, a ausência de regulamentação rigorosa sobre fitoterápicos no Brasil e a persistência do mito de que “natural não faz mal” constituem barreiras adicionais para o uso responsável da espécie. Conclui-se que *G. glaucescens* reúne atributos de interesse do seu potencial no campo da fitoterapia.

Palavras-chave: Biotecnologia. Fitoterapia. *Galactia glaucescens*. Toxicidade.

RESUMEN

Galactia glaucescens Kunth es una especie nativa de América del Sur cuyo uso tradicional se asocia principalmente con propiedades antivenenosas. Estudios recientes han demostrado la capacidad de sus extractos para neutralizar las actividades neurotóxicas y miotóxicas de los venenos de serpiente, lo que refuerza su potencial farmacológico. Sin embargo, a pesar de este creciente interés, sigue habiendo una falta de información sobre sus aspectos toxicológicos, farmacológicos y normativos. Plantas de la familia Fabaceae pueden presentar metabolitos secundarios de importancia terapéutica, pero también riesgos y efectos adversos. Esta dualidad entre beneficios y riesgos pone de relieve la necesidad de enfoques científicos más sólidos, especialmente mediante ensayos *in vitro* e *in vivo* para evaluar la genotoxicidad, la mutagenicidad y la seguridad en diferentes dosis y condiciones de exposición. En el campo biotecnológico, las técnicas de cultivo *in vitro*, la micropropagación y la metabolómica representan alternativas prometedoras para estandarizar el material vegetal e identificar compuestos bioactivos de forma segura. Además, el uso de la nanotecnología y los modelos computacionales puede contribuir a mejorar la eficacia farmacológica, reducir los efectos adversos y predecir las interacciones moleculares relevantes. No obstante, la ausencia de una regulación rigurosa sobre los medicamentos a base de hierbas en Brasil y la persistencia del mito de que «natural significa inocuo» suponen obstáculos adicionales para el uso responsable de las especies. Se concluye que *G. glaucescens* posee atributos de interés científico y terapéutico, pero su explotación segura dependerá de la integración de la farmacología, la toxicología, la biotecnología y la regulación. Superar los conceptos erróneos populares y avanzar en los estudios preclínicos y clínicos será crucial para consolidar su potencial en el campo de la fitoterapia.

Palabras clave: Biotecnología. Fitoterapia. *Galactia glaucescens*. Toxicidad.

1 INTRODUCTION

Scientific interest in medicinal plants has grown exponentially in recent decades, due to the search for safe, effective and low-cost therapeutic alternatives. In this context, species of the Leguminosae family (=Fabaceae) have been highlighted for their phytochemical diversity and pharmacological potential demonstrated in different experimental models. Among them, (Barros; Silva; Porto, 2014) *Galactia glaucescens* (Kunth) has emerged as a subject of investigations due to its pharmacological properties, especially in the management of snake envenomations and inflammatory disorders. (Dal Belo et al., 2008)

G. glaucescens has bioactive compounds with recognized antioxidant, anti-inflammatory and antineurotoxic activity, being considered a promising candidate for the development of new herbal medicines. Experimental results indicate that fractions of the plant are able to neutralize the effects of the venom of (Dos Santos et al., 2019) *Crotalus durissus terrificus*, expanding the perspective of its use as an adjuvant in serum therapies. Despite this therapeutic potential, the use of plant species is still surrounded by misperceptions, such as the belief that "natural does not cause harm". This paradigm has been questioned by recent studies demonstrating potential adverse effects of plant compounds, including hepatotoxicity, genotoxicity, and mutagenicity. Thus, it is essential to critically evaluate the safety of plants such as (Dal Belo et al., 2008) (Chan, 2003; Ekor, 2014) *G. glaucescens*, whose traditional use can hide important toxicological risks.

The presence of complex secondary metabolites gives the species both its pharmacological properties and its toxic potential. Flavonoids and alkaloids, although widely investigated as bioactive molecules, can, under certain conditions, induce oxidative stress, chromosomal instability, and DNA damage. The absence of systematic toxicogenomic studies on (Cardoso, 2017) *G. glaucescens* becomes, therefore, a relevant gap to be explored.

Recent studies in pharmacognosy have reinforced the need to investigate not only the beneficial effects of medicinal plants, but also their potential genotoxic risks. Reviews published between 2020 and 2025 highlight that the indiscriminate consumption of herbal medicines may be related to mutagenic effects that are still poorly recognized clinically. These data alert to the importance of integrating molecular toxicology methodologies into pharmacological studies of the species. (Chan, 2003; Posadzki; Watson; Ernst, 2013)

In the field of experimental pharmacology, the investigation of toxicological effects is essential to validate the safety of potential herbal medicines. Assays such as comet test, micronucleus, and chromosomal aberrations have been widely used to evaluate the genotoxic

impacts of plant extracts. Applying these methodologies to (Hartmann, 2003) *G. glaucescens* would represent an advance in the understanding of its risk profile.

In addition to the pharmacological approach, it is necessary to consider the ecological aspects associated with the use of this species. *G. glaucescens* plays an important role in tropical ecosystems, particularly due to its nitrogen fixation capacity, contributing to soil fertility and environmental restoration. However, indiscriminate exploitation for medicinal purposes can negatively impact biodiversity conservation. (Sprent ; Gehlot , 2010)

Another critical point is the accelerated growth of the global herbal medicine market, which often anticipates the scientific validation of many plant species. This expansion, associated with the popularization of natural medicine, exposes populations to the risk of consuming extracts without proof of toxicological safety. The case of (Bent, 2008; Ekor, 2014) *G. glaucescens* illustrates the need for stricter regulations.

In parallel, international regulatory bodies such as the European Medicines Agency (EMA) and the Food and Drug Administration (FDA) have strengthened requirements for preclinical genotoxicity and mutagenicity analyses before the approval of plant-derived compounds for therapeutic use. The adequacy of research on (European Medicines Agency, 2026) *G. glaucescens* to these guidelines is an essential condition for future validation of the species in clinical contexts.

In Brazil and other Latin American countries, where the traditional use of the species is reported, it is urgent to promote investigations that reconcile popular knowledge with modern scientific approaches. The rescue of ethnopharmacology needs to be linked to toxicological tests that guarantee consumer safety. This strengthens rational use and avoids risks associated with empiricism. (Bent, 2008; Posadzki; Watson; Ernst, 2013)

When analyzing the state of the art on *G. glaucescens*, it is observed a concentration of studies on its pharmacological effects, but still a significant lack of data on toxicity. This asymmetry between efficacy and safety constitutes a challenge to be overcome by the scientific community, especially in the face of the growing demands for safe and validated herbal medicines. (Chan, 2003; Dos Santos et al., 2019)

Thus, the aim of this study was to present a critical and comprehensive review of *Galactia glaucescens* (Kunth), highlighting its therapeutic properties, but also emphasizing the potential risks related to toxicity, genotoxicity and mutagenicity. It is intended, therefore, to offer subsidies for the advancement of future research and for the consolidation of the safe and rational use of this species in the contemporary pharmacological context.

2 METHODOLOGY

The present study consists of a literature review with a systematic approach and narrative character, aimed at identifying, critically analyzing, and synthesizing the scientific knowledge published between the years 2015 and 2025 on the species *Galactia glaucescens* (Kunth). The objective was to map evidence related to morphology, ecology, phytochemistry, pharmacological potential and, especially, the toxicological risks associated with its use, including aspects of toxicity, genotoxicity and mutagenicity.

The searches were carried out between August and September 2025 in widely recognized international databases, including PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, and SciELO. In order to broaden the scope and reduce publication biases, the searches were complemented with queries to Google Scholar, repositories of theses and dissertations, and technical documents available in Brazilian and international digital libraries.

To ensure terminological coverage, controlled and uncontrolled descriptors were used in Portuguese and English, according to the MeSH (Medical Subject Headings) and DeCS (Health Sciences Descriptors) vocabularies. The combinations included terms such as "*Galactia glaucescens*", "Fabaceae", "Leguminosae", "medicinal plants", "toxicity", "genotoxicity", "mutagenicity", "pharmacological potential", "natural products", "ecology" and "distribution", using Boolean operators to refine the search.

Original articles, reviews, brief communications, and book chapters published from January 2015 to May 2025, available in English, Portuguese, or Spanish, that presented specific data on *G. glaucescens* in botanical, pharmacological, toxicological, or ethnobotanical aspects, were included. Studies published before 2015, those without access to the full text, studies that mentioned only the genus *Galactia sp* without directly addressing the target species, as well as editorials, case reports, abstracts in annals of events, and gray literature without peer review were excluded.

The selection of articles followed a process in three successive stages. Initially, titles and abstracts were evaluated for relevance and adherence to the theme. Then, the full texts of potentially eligible studies were examined in depth. Finally, two independent reviewers applied the inclusion and exclusion criteria rigorously, and any divergences were resolved by consensus.

The extracted data were systematized in a standardized spreadsheet, including information such as author, year of publication, country of origin, indexing base, methodological design, objectives, main results and conclusions. The organization of the information allowed the categorization of the findings into five main axes: botany and morphology; geographic

distribution and ecology; phytochemistry and secondary metabolites; pharmacological potential, including studies on antivenom, antioxidant and anti-inflammatory effects; and toxicity, with emphasis on genotoxicity and mutagenicity analyses.

The synthesis of the data was carried out in a narrative and integrative way, seeking to relate trends, advances and gaps in the recent literature. Priority was given to studies published in the period from 2015 to 2025, although some previous works were mentioned punctually for historical and complementary contextualization.

3 LITERATURE REVIEW

3.1 BOTANICAL AND TAXONOMIC ASPECTS

The genus *Galactia* groups approximately 50 species described in tropical regions. Of these, about 45 species are distributed in Tropical America. According to

Beyra Matos et al. (2005) little is known about the economic applications of the species belonging to this genus. The species *Galactia glaucescens* belongs to the class Dicotyledoneae, which includes angiosperms that are characterized by developing two cotyledon leaves in the seed embryo; family Leguminosae (=Fabaceae), which comprises one of the largest families among the dicots with more than 600 genera. The plant stands out for its pharmacological potential and the complexity of its botanical characterization. Floristic studies in the state of São Paulo have shown the occurrence of different species of the genus (Joly, 2005) *Galactia*, but have not recorded the presence of *G. glaucescens*, pointing to gaps in knowledge about its geographic distribution. This absence in regional surveys highlights the need to expand taxonomic and ecological investigations, especially to support future therapeutic uses in a responsible manner. (Portal Plantas do Brasil, 2026)

In Brazil, the species *Galactia glaucescens* is found in the cerrado and is distributed mainly in ecotonal areas of this biome, as in the state of Tocantins. According to the BIOTA program developed by the Foundation for Research Support of the State of São Paulo and according to a resolution of the Department of the Environment of the same state, the plant ("BIOTA-FAPESP Program", [Undated]) (Legislation, 2022) *G. glaucescens* is on the list of species of flora in the state of São Paulo threatened with extinction.

In the state of Tocantins there is no study on the population density of this species. However, in an ethnobotanical survey carried out by Barra D'Aroeira, the use of *G. glaucescens* leaves (vernacular Three Leaves) by healers belonging to the community of black remnants Barra D'Aroeira, located in the municipality of Santa Tereza, Tocantins, in the treatment of snakebite envenomation was identified. The

vernacular "three leaves" was attributed by the healers of this community due to the plant having a leaf blade divided into three independent leaflets.

Its taxonomic classification is supported by international databases such as the NCBI Taxonomy Browser, which places the species in the group of Papilionoideae, highlighting its relationship with legumes of ecological importance. Despite the consolidated systematic positioning, there are still challenges in the chemical and pharmacological characterization of the species. This reality reinforces the maxim that botanical identification, although essential, does not ensure safety of use, and it is essential to deepen toxicological studies. (NCBI Taxonomy Browser, 2026)

3.2 ANATOMY AND HISTOCHEMISTRY

Anatomy and histochemistry surveys of vegetative organs of *G. glaucescens* demonstrated the presence of specialized secretory structures and phenolic compounds distributed in different tissues, confirming its pharmacological potential. Such findings corroborate the interest in the species as a source of bioactive metabolites. However, the production of these substances must be analyzed from a critical perspective, since natural compounds can also trigger adverse effects on biological systems. (Barros; Silva; Porto, 2014)

The histochemical characterization showed a predominance of flavonoids, alkaloids and phenolic derivatives, which are often associated with antioxidant and cellular protective effects. Despite these potential benefits, there is evidence in the literature that these same chemical groups can exert genotoxic activities, especially at high doses or in prolonged exposures. Thus, the study of histochemistry not only provides support for therapeutic uses, but also warns of risks intrinsic to the indiscriminate use of the species. (Barros; Silva; Porto, 2014)

3.3 PHARMACOLOGICAL PROPERTIES AND ETHNOBOTANICAL USES

The pharmacological potential of *G. glaucescens* includes antivenom activities, with promising results against certain effects of the venom of the snake *Crotalus durissus terrificus* (Dal Belo et al., 2008; Gómez-Murillo; Arellano-Martín, 2021 ; Sumedh et al., 2018). These effects strengthen the perspective of using the plant as a complementary therapeutic resource in endemic regions, where snakebites represent a serious public health problem. However, studies remain incipient and lack further study on safety and clinical applicability.

From the ethnobotanical point of view, records in the Pantanal region point to the use of plants of the genus *Galactia* in traditional practices. These reports, although relevant to

ethnopharmacology, should be interpreted with caution, since popular knowledge tends to reinforce the mistaken notion that "natural does no harm". Without robust investigations into toxicity, genotoxicity and mutagenicity, the consumption of these plants may imply silent health risks. (Pott ; Pott , 1995)

3.4 DIVERSITY, CONSERVATION AND GAPS

Broader studies on legume diversity in the Gran Chaco highlight the importance of legumes as a whole and the existence of several endemic species, but do not include specific data on *G. glaucescens*, underscoring the paucity of detailed research on the species. This lack of data reinforces the urgency of systematic studies that consider both the pharmacological potential and the toxicological risks associated with the species. (C Eolin ; M iotto , 2013)

Although the genus *Galactia*, as well as other Fabaceae, has potential for the discovery of bioactive compounds, there are still no studies directed to *G. glaucescens* — highlighting a gap in knowledge (Carvalho et al., 2008) However, more general research shows the complexity of these species, which can concentrate biologically active molecules with effects that are not only beneficial, but also potentially harmful. The balance between benefit and risk, therefore, needs to be investigated with greater scientific rigor.

3.5 POLLEN MORPHOLOGY AND TOXICOLOGICAL IMPLICATIONS

The analysis of the pollen morphology of the genus *Galactia* sp, including Brazilian representatives, provides subsidies to understand its diversification and phylogenetic relationship with other legumes. This type of characterization, in addition to having taxonomic implications, can help in understanding the biosynthetic pathways responsible for the production of secondary metabolites. Such pathways are precisely the ones that determine the bioactivity and toxicity profile of compounds present in (Roubik; Moreno, 1991 ; Bishop of the Santos, 2014) *G. glaucescens*.

Analysis of the pollen morphology of representatives of the genus *Galactia*, including *G. glaucescens*, reveals features—such as perforated murus—that may be useful for distinguishing this species from others and inferring phylogenetic relationships and potential metabolic correlations. The characterization of these structures contributes to identifying potential correlations with the synthesis of molecules that, while having therapeutic properties, can trigger genotoxic or mutagenic effects. In this sense, morphological and biochemical analysis must be interpreted in an integrated way, reinforcing the central debate about the risks

embedded in the belief that natural substances are harmless. (Roubik; Moreno, 1991 ; Bishop of the Santos, 2014)

3.6 ECOLOGY AND GEOGRAPHICAL DISTRIBUTION OF *GALACTIA GLAUDESCENS*

Recent taxonomic studies, such as that of Ceolin & Miotto (2013), provide a synthesis of the genus *Galactia* in Brazil and present relevant data for *G. glaucescens*, such as its synonymy and distribution. In addition, the formal description of the species in the Plazi TreatmentBank provides essential information about its typification, morphological variation, and relationship with other species of the genus. (Ceolin; Miotto, 2013) (“*Galactia glaucescens*”, Prefix Match - Plazi TreatmentBank”, [Undated])

The absence of consistent data on the geographic range of the species has a direct impact on the risk analyses associated with its use. Plants of restricted distribution tend to accumulate secondary metabolites at differentiated concentrations, a result of local environmental pressures. Such chemical changes can ultimately modify its toxicological profile. The ethnobotanical literature indicates that traditional populations often use species of the genus (Gobbo-Neto; Lopes, 2007) *Galactia* without clear taxonomic distinction, which can lead to the misuse of plants with potential adverse effects. This overlap in popular knowledge reinforces the urgency of detailed investigations into the identity and risks of (De Albuquerque et al., 2007) *G. glaucescens*.

From an ecological point of view, it is notable that Fabaceae species, when occupying marginal niches, often synthesize bioactive compounds as a defense strategy against herbivory. In (Wink, 2013) *G. glaucescens*, this characteristic can be interpreted as a pharmacological advantage, but also a warning of genotoxic risks. In addition, anthropogenic changes in ecosystems, such as deforestation and fragmentation, may be further restricting the distribution of *G. glaucescens*. Such environmental pressures often intensify the production of defense metabolites, increasing the need for toxicity monitoring. This interface between ecology and pharmacology cannot be neglected. (Bravo-Monzón et al., 2022)

Pollination ecology is also related to the availability of the species. Studies on pollen morphology indicate that *Galactia* has specific patterns that influence its dispersion. Alterations in this process can compromise natural reproduction and reduce genetic variability, a relevant factor for biochemical and toxicological potential. Finally, the restricted distribution and ecological challenges faced by the species reinforce the need for multidisciplinary approaches. Without robust data on its occurrence, it becomes impossible to accurately assess both the therapeutic potential and the risks associated with indiscriminate use. This reinforces the

centrality of the debate about the myth that natural products are necessarily safe. (Veasey et al., 1999) (“ *Galactia glaucescens* Kunth | Plants of the World Online | Kew Science”, 2026)

The ecology of *G. glaucescens*, therefore, should not be seen only as a field of botanical interest. It is an essential element for understanding its pharmacological safety and for the formulation of public policies that reconcile conservation and sustainable use. The integration of ecological, taxonomic and toxicological data is, in this sense, an indispensable path. (Clement et al., 2010)

3.7 POTENTIAL HERBAL MEDICINES AND SAFETY LIMITATIONS

The use of *Galactia glaucescens* in traditional healing practices in Brazil is documented by communities that employ it mainly in disorders related to inflammatory processes and snakebites. The reported pharmacological potential is in line with the presence of bioactive metabolites that act on neuronal and enzymatic receptors. While this ethnobotanical knowledge is valuable, its transposition into clinical settings requires rigorous toxicological studies. (Calixto, 2000)

Preclinical trials have demonstrated antineurotoxic activity of plant extracts against the venom of *Crotalus durissus terrificus*, suggesting its application as an adjuvant in snakebite treatments. This result, however, should not be interpreted as a guarantee of safety, since pharmacological efficacy may coexist with risks of systemic toxicity and genotoxicity. (Dal Belo et al. , 2008)

The appreciation of native flora as a therapeutic resource is growing, driven by the global movement in favor of phytotherapy. However, this scenario favors the spread of the mistaken belief that natural is free of adverse effects. In the case of (Ekor, 2014) *G. glaucescens*, this perception can induce consumption without adequate scientific support, exposing users to potential risks of mutagenicity.

The concept of "relative safety" in herbal medicines is particularly sensitive, as different methods of preparation — infusion, decoction or alcoholic extracts — can substantially modify the concentration of active and toxic compounds. Thus, the same plant material may have divergent profiles in terms of efficacy and risk. Recent pharmacological research highlights the importance of isolating and characterizing the compounds responsible for the effects attributed to the plant. In (Firenzuoli; Gori, 2007) *G. glaucescens*, flavonoids and alkaloids are among the leading candidates. Even so, many of these chemical groups have reports in the literature

of potential genotoxic effects, which reinforces the need for careful evaluation. (Pott ; Pott , 1995)

The risk of popular use of plant species is not restricted to the intrinsic toxicity of the metabolites. External factors, such as contamination by heavy metals, pesticides, or microorganisms during collection and processing, can further increase the deleterious effects. This indicates that the issue of safety goes beyond the species itself, encompassing the entire production and use chain. (Street, 2012)

Another central point is the absence of specific regulations on the commercialization of products derived from *G. glaucescens*. Without official quality control protocols, variability in extracts compromises both therapeutic efficacy and toxicological evaluation. Such regulatory fragility reinforces the urgency of standardized studies. The literature on herbal medicines highlights that plants with recognized therapeutic potential also have reports of adverse effects in cell and animal models, including DNA damage and chromosomal instability. In this context, (World Health Organization, 2007) (Wagner; Ulrich-Merzenich, 2009) *G. glaucescens* should be studied from the same perspective, aiming to identify genotoxic risks early.

In addition to direct toxicity, the possibility of drug interactions is an aspect that is often overlooked. Bioactive compounds of *G. glaucescens* may interfere with metabolic pathways of conventional drugs, increasing clinical risks. This pharmacological dimension should be incorporated into future research protocols. Therefore, although the herbal potential of (Williamson, 2003) *G. glaucescens* is promising, it cannot be dissociated from the need for scientific rigor. The popular discourse that "natural does no harm" lacks support when confronted with the growing evidence of toxicological, mutagenic and genotoxic risks. The consolidation of safe use will depend on the integration between pharmacology, toxicology and regulatory policies. (Efferth; Koch, 2011)

3.8 TOXICOLOGICAL RISKS: GENOTOXICITY AND MUTAGENICITY

The safety of the use of *Galactia glaucescens* requires special attention in the field of toxicology. Plants of the Fabaceae family are known for the production of compounds with relevant pharmacological activity, but may also contain potential adverse effects. In the case of (Susilawati et al., 2023) *G. glaucescens*, the scarcity of specific studies on safety reinforces the need for systematic investigations that consider cellular and molecular parameters. The genotoxic risk associated with secondary metabolites is widely documented in plant species. Flavonoids, for example, have antioxidant activity, but under certain conditions they can induce DNA damage and generate genomic instability. This duality requires caution in interpreting the

benefits attributed (López-Lázaro, 2007) to *G. glaucescens*, since positive and adverse effects can coexist.

In vitro *experimental models* represent a valuable tool to evaluate genotoxicity and mutagenicity of plant extracts. However, in the case of (Pfuhler et al., 2009) *G. glaucescens*, such studies are still incipient, limiting the understanding of the real risk potential. The absence of micronucleus assays, comet testing, or chromosomal aberrations represents a relevant gap that must be filled.

Popular use without scientific backing exposes individuals to invisible risks. The mutagenic effects of plant compounds may not manifest immediately, but accumulate over time, increasing the likelihood of developing chronic diseases, including cancer. This dimension reinforces the urgency of breaking the paradigm that medicinal plants are inherently safe. (Stich; Rosin, 1984)

Another critical point refers to reproductive toxicity. Some legumes have compounds capable of interfering with fertility and embryonic development. Considering the phytochemical similarity between species of the genus (Hughes Jr, 1988) *Galactia*, it is plausible that *G. glaucescens* shares characteristics that require experimental evaluation. Toxicity should not be analysed solely from the perspective of high doses. Recent studies highlight that even subtherapeutic concentrations of some herbal medicines can induce mutations when exposure is chronic. This perspective magnifies the challenges in defining safe limits for long-term use of (European Food Safety Authority, 2010) *G. glaucescens* extracts.

The risk of genotoxic interactions also extends to the environmental context. Bioactive compounds released by plant species can interfere with soil microorganisms and, in the long term, affect food chains. This relationship between ecotoxicology and human safety has not yet been explored for (Duke; Dayan, 2011) *G. glaucescens*, but it should be considered in multidisciplinary approaches. It is also necessary to highlight the absence of regulatory protocols that require mutagenicity tests before the commercialization of herbal medicines in Brazil. This gap opens space for the circulation of potentially harmful products, without robust evidence of safety. In the case of (Mattei et al., 1998) *G. glaucescens*, the risk is amplified by the lack of standardization in preparation and dosage methods.

In parallel, recent reviews on medicinal plants highlight that the underreporting of adverse events compromises the real safety assessment. Often, genotoxicity-related side effects are not directly attributed to plant consumption, making epidemiological screening difficult. This phenomenon may be hiding the impacts of the indiscriminate use of (De Sousa, 2023) *G. glaucescens*.

Thus, the discussion about the toxicological risks associated with any herbal compound, such as *G. glaucescens*, needs to be broadened, integrating molecular biology, regulatory toxicology and pharmacovigilance methods. Only in this way will it be possible to counteract in a reasoned way the popular argument that "natural does not hurt" and build solid foundations for the responsible use of this species. (Rodrigues; Barnes, 2013)

3.9 FUTURE PHARMACOLOGICAL PERSPECTIVES AND BIOTECHNOLOGY

Biotechnology has expanded the possibilities for safe exploitation of medicinal plants, including *Galactia glaucescens*. Modern techniques of *in vitro* cultivation and micropropagation allow the achievement of standardized plant biomass, reducing phytochemical variability and favoring more consistent pharmacological studies. This advance may contribute to isolating compounds of therapeutic interest with greater safety. In addition to standardization, biotechnology enables the genetic manipulation of plant species in order to reduce potentially toxic compounds, maintaining the production of relevant bioactive metabolites. For (Fazili et al., 2022) (Georgiev et al., 2012) *G. glaucescens*, this represents a promising path, since the coexistence of therapeutic properties and genotoxic risks limits its full use.

Nanotechnology emerges as another strategic tool for plant pharmacology. The encapsulation of plant extracts in nanoparticles can reduce adverse effects, control the release of active ingredients and increase bioavailability. These approaches would demonstrate efficacy in other Fabaceae, which reinforces their potential application. (Srinivasan, 2023)

Still, pharmacological development requires strict safety protocols. Preclinical and clinical trials should be conducted to verify toxicity in cellular and animal systems prior to transposition to human therapies. The absence of such studies for (Martins et al., 2011). *G. glaucescens* highlights a barrier that must be overcome. Another emerging field is metabolomics, which enables the global analysis of the compounds present in the plant. Applied to *G. glaucescens*, this technique would make it possible to identify both molecules with therapeutic potential and those associated with genotoxicity. This systemic view is essential to advance in the balance between benefits and risks. (Wolfender et al., 2015)

Bioprospecting for natural compounds faces ethical challenges, especially when it involves traditional knowledge from local communities. The use of this knowledge must respect the principle of fair sharing of benefits, avoiding undue exploitation of ancestral knowledge. This ethical dimension is inseparable from pharmacological advances. On the other hand, the growing demand for natural products in the global market increases the pressure for rapid scientific validation of new species. This scenario can favor methodological shortcuts that

compromise security. For (Singh; Pathak; Rai, 2022) (Tilburt, 2008) *G. glaucescens*, it is essential that the commercial rush does not supplant the need for robust toxicological tests.

The integration between pharmacology and bioinformatics also opens horizons for the species. Molecular modeling can predict interactions of *G. glaucescens* compounds with biological targets, anticipating potential therapeutic and adverse effects. This approach allows prioritizing safer molecules for future assays. The biotechnological perspective should not be seen as a substitute for traditional studies, but as a necessary complement. Technological advancement can optimize the investigation of (Sliwoski et al., 2014) *G. glaucescens*, as long as it is accompanied by appropriate toxicological evaluations. This synergy is indispensable to transform the plant's potential into safe clinical applications. (Atanasov et al., 2021)

In short, the pharmacological prospects of *G. glaucescens* are promising, but the future of the species in the field of phytotherapy will depend on the ability to reconcile biotechnological innovation and scientific rigor. Without this, there is a risk of perpetuating the cycle of exploitation of medicinal plants with proclaimed benefits, but invisible risks. (Newman; Cragg, 2020)

3.10 THE SCIENTIFIC DEBATE ABOUT "NATURAL DOES NOT HURT"

The discourse that natural products are risk-free remains rooted in the popular imagination, but the scientific literature increasingly demonstrates that this belief is mistaken. In the case of *Galactia glaucescens*, the therapeutic potential is accompanied by uncertainties regarding toxicity and genotoxicity. This duality needs to be clearly communicated to society. (Veiga Junior; Pinto; Maciel, 2005)

The popularization of herbal medicines often relies on arguments of cultural tradition and historical use, without considering that long-term adverse effects have rarely been systematically documented in traditional contexts. This perception bias contributes to the perpetuation of the idea of absolute security. (De Smet, 2002)

The precautionary principle should guide the exploitation of *G. glaucescens*. The absence of conclusive studies is not equivalent to proof of harmlessness. On the contrary, the lack of evidence should be understood as a warning of the risk of inadvertent exposure to mutagenic substances. Scientific communication plays a central role in this debate. It is necessary to counter the marketing narrative, which often reinforces the appeal to "natural", with data from toxicological research that shows potential risks. Only then will it be possible to rebalance public perception. From a regulatory point of view, the weakness in the supervision

of the commercialization of natural products amplifies the problem. Herbal medicines derived from species with knowledge gaps, such as (World Health Organization, 2007) (Izzo; Ernst, 2001) *G. glaucescens*, can reach the market without any proof of safety. This reality poses challenges to public health. (Shaw, 2010)

The myth of "natural does not hurt" also impacts the behavior of patients who use herbal medicines in combination with conventional medicines. The resulting interactions can compromise established pharmacological therapies, generating serious consequences. This risk is still little explored in studies on (Fugh-Berman, 2000) *G. glaucescens*. Recent research in toxicology has shown that the indiscriminate consumption of medicinal plants may be associated with increased markers of genomic instability in exposed populations. This evidence reinforces that the discussion goes beyond hypotheses and approaches measurable impacts. (Cruz, 2015)

It should be noted that modern pharmacology has already demonstrated that many synthetic compounds derived from plants were only accepted after rigorous toxicological evaluation. Thus, there is no justification for not applying the same rigor to species such as (Butler, 2008) *G. glaucescens*. The scientific debate, therefore, is not about denying the potential benefits of medicinal plants, but about recognizing that benefits and risks coexist. For *G. glaucescens*, this duality is especially evident and needs to be addressed in a transparent way. (Capasso et al., 2000)

It is concluded that overcoming the myth "natural does no harm" is an indispensable condition for the safe use of *G. glaucescens*. The integration between ethnobotany, pharmacology, toxicology and scientific communication will be the way to transform this species into a reliable therapeutic resource, without compromising collective health. (Jordan; Cunningham; Marles, 2010)

4 CONCLUSION

The analysis of *Galactia glaucescens* shows a central duality: while it has relevant pharmacological properties, such as antivenom and antioxidant activities, it also brings uncertainties regarding its toxic and genotoxic potential. This ambivalence reinforces the need for their use to be accompanied by rigorous scientific protocols, especially in a scenario in which the valorization of natural products is still permeated by myths of absolute safety.

Future perspectives indicate that biotechnology, nanotechnology and metabolomics can play fundamental roles in the safer and more effective exploitation of the species, allowing both the standardization of extracts and the identification and isolation of bioactive compounds with

lower toxicological risk. However, such advances will only be relevant if accompanied by an ethical approach, which respects traditional knowledge and avoids the predatory exploitation of natural resources.

Overcoming the popular imagination that "natural does no harm" is an indispensable condition to transform *G. glaucescens* into a reliable therapeutic resource. This requires integration between ethnobotany, pharmacology, toxicology, biotechnology, and scholarly communication, in order to balance risks and benefits. Thus, the future of the species in the field of phytotherapy will depend not only on technological innovation, but also on scientific and regulatory responsibility to ensure its safety and effectiveness.

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THE ROLE OF MUSCLE GLYCOGEN UNDER LOW ENERGY AVAILABILITY AND ITS IMPACT ON PERFORMANCE IN FUNCTIONAL SPORTS: A SYSTEMATIC REVIEW

O PAPEL DO GLICOGÊNIO MUSCULAR EM CONDIÇÕES DE BAIXA DISPONIBILIDADE ENERGÉTICA E SEU IMPACTO NO DESEMPENHO EM ESPORTES FUNCIONAIS: UMA REVISÃO SISTEMÁTICA

EL ROL DEL GLUCÓGENO MUSCULAR EN CONDICIONES DE BAJA DISPONIBILIDAD ENERGÉTICA Y SU IMPACTO EN EL RENDIMIENTO EN DEPORTES FUNCIONALES: UNA REVISIÓN SISTEMÁTICA



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ABSTRACT

Introduction: Low energy availability (LEA) and reduced muscle glycogen are recognized as key determinants of performance and health in athletes practicing functional sports, which are characterized by high training density and mixed metabolic demands. This systematic review aimed to synthesize the available evidence on the relationship between LEA, muscle glycogen status, and physical performance in functional sports.

Methods: A systematic review was conducted following PRISMA 2020 guidelines. A search was performed in PubMed/MEDLINE, Scopus, and Web of Science (January 2015–October 2025). Twelve studies involving trained adults were included. Data extraction and risk of bias assessment were performed by a single reviewer. Due to methodological heterogeneity, a descriptive quantitative synthesis was conducted.

Results: Four studies (33%) directly assessed muscle glycogen, showing that a 30–40% depletion was associated with 8–15% reductions in high-intensity performance. Five studies (42%) identified LEA associated with decreased leptin and triiodothyronine levels and increased cortisol. Physiological demands in functional sports included oxygen consumption of 85–92% of VO_2max and lactate concentrations exceeding 10–12 mmol/L.

Conclusions: Evidence indicates that LEA and reduced muscle glycogen consistently impair performance and recovery in functional sports, highlighting the need to distinguish between total energy availability and carbohydrate availability in nutritional planning.

Keywords: Energy Availability. Athletic Performance. Nutrition.

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RESUMO

Introdução: A baixa disponibilidade energética (LEA) e a redução do glicogênio muscular são reconhecidas como fatores determinantes do desempenho e da saúde em atletas que praticam esportes funcionais, caracterizados por elevada densidade de treinamento e demandas metabólicas mistas. O objetivo desta revisão sistemática foi sintetizar as evidências disponíveis sobre a relação entre LEA, o estado do glicogênio muscular e o desempenho físico em esportes funcionais.

Métodos: Foi realizada uma revisão sistemática seguindo as diretrizes PRISMA 2020. A busca foi conduzida nas bases PubMed/MEDLINE, Scopus e Web of Science (janeiro de 2015 a outubro de 2025). Foram incluídos doze estudos com adultos treinados. A extração dos dados e a avaliação do risco de viés foram realizadas por um único revisor. Devido à heterogeneidade metodológica, foi realizada uma síntese quantitativa descritiva.

Resultados: Quatro estudos (33%) avaliaram diretamente o glicogênio muscular, observando-se que uma depleção de 30–40% esteve associada a reduções de 8–15% no desempenho de alta intensidade. Cinco estudos (42%) identificaram LEA associada a diminuições de leptina e triiodotironina e aumentos de cortisol. As demandas fisiológicas em esportes funcionais incluíram consumos de oxigênio de 85–92% do $\text{VO}_{2\text{máx}}$ e concentrações de lactato superiores a 10–12 mmol/L.

Conclusões: As evidências indicam que a LEA e a redução do glicogênio muscular comprometem de forma consistente o desempenho e a recuperação em esportes funcionais, destacando a necessidade de diferenciar entre disponibilidade energética total e disponibilidade de carboidratos no planejamento nutricional.

Palavras-chave: Disponibilidade Energética. Desempenho Esportivo. Nutrição.

RESUMEN

Introducción: La baja disponibilidad energética (LEA) y la reducción del glucógeno muscular se reconocen como factores determinantes del rendimiento y la salud en atletas que practican deportes funcionales, caracterizados por una elevada densidad de entrenamiento y demandas metabólicas mixtas. El objetivo de esta revisión sistemática fue sintetizar la evidencia disponible sobre la relación entre LEA, el estado del glucógeno muscular y el rendimiento físico en deportes funcionales.

Métodos: Se realizó una revisión sistemática siguiendo las directrices PRISMA 2020. Se efectuó una búsqueda en PubMed/MEDLINE, Scopus y Web of Science (enero de 2015–octubre de 2025). Se incluyeron doce estudios en adultos entrenados. La extracción de datos y la evaluación del riesgo de sesgo fueron realizadas por un único revisor. Debido a la heterogeneidad metodológica, se efectuó una síntesis cuantitativa descriptiva.

Resultados: Cuatro estudios (33%) evaluaron el glucógeno muscular de forma directa, observándose que una depleción del 30-40% se asoció con reducciones del 8-15% en el rendimiento de alta intensidad. Cinco estudios (42%) identificaron LEA asociada con disminuciones de leptina y triyodotironina y aumentos de cortisol. Las demandas fisiológicas en deportes funcionales incluyeron consumos de oxígeno del 85-92% del $\text{VO}_{2\text{máx}}$ y concentraciones de lactato superiores a 10-12 mmol/L.

Conclusiones: La evidencia indica que la LEA y la reducción del glucógeno muscular comprometen de manera consistente el rendimiento y la recuperación en deportes funcionales, destacando la necesidad de diferenciar entre disponibilidad energética total y disponibilidad de carbohidratos en la planificación nutricional.

Palabras clave: Disponibilidad Energética. Rendimiento Deportivo. Nutrición.

1 INTRODUCTION

Energy availability is conceptualized as the embodied energy minus the energy cost associated with exercise, adjusted according to fat-free mass, thus constituting a determining factor of physiological functionality in athletes. In cases where such a relationship leads to temporarily sustained insufficiencies, low energy availability (LEA) occurs, related to an overall energy imbalance that entails the compromise of the energy required for basal metabolism processes, as well as for systemic homeostasis (1). LEA is a pathophysiological structuring factor of Relative Energy Deficiency Syndrome in Sport (RED-S), associated with systemic alterations, whether endocrine, metabolic, immunological, bone and cardiovascular, thus directly affecting health and performance (1,2). It is of great importance to differentiate this concept from carbohydrate availability (CHO), which is associated with the provision of carbohydrates for exercise and recovery, as well as from low-CHO or ketogenic diets, the latter being nutritional strategies aimed at restricting such intake. It should be emphasized that such terms are not equivalent, given that although LEA implies a total energy deficit, the reduced availability of CHO is potential even with an adequate caloric intake, always dependent on the context and physiological objective (8,9).

In female athletes, LEA is especially relevant due to its association with the Female Athlete Triad, given by LEA, menstrual dysfunction and reduced bone mineral density (3). Specifically, sustained LEA leads to alterations in pulsatile secretion of GnRH, decreases concentrations of luteinizing hormone (LH) and follicle-stimulating hormone (FSH), and affects ovarian function, all in conjunction with reductions in leptin and triiodothyronine (T3), and increases in cortisol (adaptive catabolic state) (1,3). Although these reactions are aimed at preserving energy survival, their sustained presence entails compromises on bone health, reproductive function, post-exercise recovery, and immune homeostasis and the risk of injury and psychological damage (2,4). These repercussions derive from the overall deficit of the LEA, not individually from the restriction of CHO, thus finding a mechanistic differentiation between the constructs in question.

From a performance perspective, the availability of CHO has a central function in determining glycogen content and localization at the muscle level; that is, the most important energy component in high-intensity exercise: adenosine triphosphate (ATP) resynthesis (glycogenolysis), regulation of muscle contraction, calcium release, metabolic signaling (5-7). Studies affirm that glycogen depletion, at any level, is likely to reduce force generation, as well as produce the acceleration of fatigue, regardless of the total depletion of reserves (6,7). In this way, the low availability of CHO alters acute performance; on the other hand, LEA increases

this effect by limiting glycogen resynthesis and favoring a catabolic hormonal environment (lower insulin and leptin, higher cortisol) (1,2,8).

In accordance with the theme of this study, such interactions are of great relevance in functional and hybrid patterns such as CrossFit, Hyrox and concurrent instances of strength and endurance (high working density and glycolytic requirements, and recovery with limitations). Whether in CrossFit (performance associated with previous glycogen stores and replenishment capacity between consecutive sessions) (6,10), or in Hyrox (need for sustained glycogen availability towards sustaining intensity) (11), the overlap between LEA and low CHO availability is decisively detrimental, since the global energy deficit affects chronic adaptive capacity and health. In addition to the fact that the CHO restriction delimits short-term performance, as well as work capacity. In this sense, energy and substrate levels should be differentiated in nutritional planning, as well as any modality of CHO restriction should be justified in correspondence with the physiological mechanism and the training objective, towards the avoidance of temporarily sustained energy deficits likely to increase the risk of RED-S and performance impairment (8,9).

Taken together, the evidence suggests that muscle glycogen constitutes a central determinant of performance in functional sports, and that LEA, by limiting its availability, establishes a scenario of physiological vulnerability that compromises power, endurance and resilience. Understanding how these factors are interrelated is essential for designing nutritional and training strategies that optimize adaptation and minimize the adverse effects of energy deficiency. Therefore, the present study aims to analyze the role of glycogen in the context of low energy availability and its impact on the performance and health of athletes in functional disciplines, through a systematic review based on PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (12).

2 METHODOLOGY STUDY DESIGN

A systematic review of the literature was carried out in accordance with the guidelines established by the PRISMA 2020 guideline (12). The aim was to synthesize current evidence on the relationship between LEA, muscle glycogen status, and performance-related outcomes in functional sports.

2.1 SOURCES OF INFORMATION AND SEARCH STRATEGY

The search was carried out in the PubMed/MEDLINE, Scopus and Web of Science databases, justifying by its treatment of studies in sports science, exercise physiology and sports nutrition.

The searches themselves were conducted in September-October 2025, including studies published in the period January 2015-October 2025, regardless of geographical context. Research published in both English and Spanish was considered.

The survey strategy included the combination of controlled terms (MeSH) and free keywords, involving the use of Boolean AND and OR operators, discriminated according to the database. Thus, for PubMed/ MEDLINE, MeSH terms and free text were used in Title/Abstract fields: ("Low Energy Availability"[Title/Abstract] OR "energy availability"[Title/Abstract] OR "relative energy deficiency in sport"[Title/Abstract] OR RED-S[Title/Abstract] OR "Energy Metabolism"[Mesh]) AND ("Muscle Glycogen"[Mesh] OR "muscle glycogen"[Title/Abstract] OR "glycogen depletion"[Title/Abstract] OR "glycogen resynthesis"[Title/Abstract]) AND ("Athletes"[Mesh] OR athlete*[Title/Abstract] OR "trained individuals"[Title/Abstract] OR "high-intensity functional training"[Title/Abstract] OR "functional training"[Title/Abstract] OR CrossFit[Title/Abstract] OR Hyrox[Title/Abstract] OR "high-intensity interval exercise"[Title/Abstract]) AND ("Sports Performance"[Mesh] OR performance[Title/Abstract] OR fatigue[Title/Abstract] OR recovery[Title/Abstract]).

In Scopus, we used TITLE-ABS-KEY search: (title-abs-key("low energy availability" OR "energy availability" OR "relative energy deficiency in sport" OR "RED-S")) and (title-abs-key("muscle glycogen" OR "glycogen depletion" OR "glycogeresynthesis"))AND (TITLE-ABS-KEY("functional training" OR "high intensity functional training" OR "high intensity interval exercise" OR CrossFit OR Hyrox OR athlete* OR "trained individuals")) AND (TITLE-ABS-KEY(performanceORfatigueOR recovery OR "exercise performance")).

Finally, in Web of Science, a Topic (TS) search was used: TS=("low energy availability" OR "energy availability" OR "relative energy deficiency in sport" OR RED-S) and TS=("muscle glycogen" OR "glycogen depletion" OR "glycogen resynthesis") AND TS=("functional training" OR "high intensity functional training" OR CrossFit OR Hyrox OR athlete* OR "trained individuals") AND TS=(performance OR fatigue OR recovery OR "exercise performance").

2.2 ELIGIBILITY CRITERIA

The following inclusion criteria were considered: studies conducted in adult humans (≥ 18 years), athletes, or physically trained; studies that directly or indirectly assessed muscle glycogen through validated techniques; studies evaluating energy availability, LEA and/or

nutritional interventions for the modification of energy infestation or CHO; studies with outcomes associated with physical performance, fatigue, work capacity, recovery, and/or adjacent physiological responses; experimental, quasi-experimental, observational designs or systematic reviews with explicit methodology.

On the other hand, the following were excluded: studies carried out in animals and/or cell models; studies carried out in pediatric populations; case studies, editorials, letters to the editor, and/or narrative reviews; studies conducted without peer review; studies with insufficient methodological information for quantitative data extraction or risk of bias assessment.

Thus, the review included studies with different methodological designs (experimental, observational and systematic reviews) given the need to cover more fully the evidence related to the problem, while, in this field of research, the scientific data generated come from diverse methodological approaches. In other words, it is considered that the restriction to a single design variant would have entailed limitations on the comprehensive understanding of the problem addressed.

2.3 SELECTION PROCESS

The identified research was imported into a bibliographic manager, the duplicates being eliminated both manually and automatically.

The selection of studies was carried out in the four phases given by PRISMA 2020 (12), in terms of identification, screening by title and abstract, full-text eligibility assessment and final inclusion.

The entire selection process was carried out by a single reviewer, in accordance with the criteria presented. In order to reduce the risk of selection bias, the application of the criteria was systematic and consistent in the stages of the process in question. The included and excluded studies by phase were documented from a PRISMA 2020 flowchart.

2.4 DATA EXTRACTION

Data extraction was carried out by a single reviewer from a standardized spreadsheet, extracting: author and year of publication; sample size and characteristics of the population; study design; method of evaluation of muscle glycogen and/or energy availability; reported quantitative outcomes (means, standard deviations, percentages, and p-values, where available); limitations.

Statistical analysis and synthesis of results

A quantitative descriptive synthesis of the data surveyed was carried out, while the extraction of percentage changes, absolute differences and statistical significance when (when available).

Considering that the included studies corresponded to significant heterogeneity in terms of design, glycogen quantification techniques, analysis of energy availability, population and outcome variables, a statistical meta-analysis was not performed.

The descriptive quantitative synthesis was based on the identification of consistent patterns regarding the relationship between the decrease in energy availability, that of muscle glycogen and the detriment of performance in functional sports, omitting aggregate statistical inferences.

2.5 ASSESSMENT OF METHODOLOGICAL QUALITY AND RISK OF BIAS

These analyses were carried out by a single reviewer, always depending on the design of each of the included studies. Thus, experimental trials were evaluated using the PEDro scale, while observational research was carried out using ROBINS-I and systematic reviews were carried out using ROBIS.

It is important to clarify that, although the analyses were not carried out independently by various reviewers, the implementation of validated techniques resulted in structured and transparent assessments of risk of bias.

On the other hand, the overall certainty of the evidence was analyzed qualitatively based on the GRADE approach, based on risk of bias, consistency, precision, and applicability to functional sports.

Considering that the present review was carried out based on studies with different methodological designs, the GRADE evaluation was implemented qualitatively at the level of narrative synthesis, incorporating all the available evidence on the relationship between energy availability, muscle glycogen and performance in functional sports. Thus, experimental studies were interpreted as higher-level evidence, while observational studies were interpreted as moderate-to-low-level evidence, although they could be adjusted in correspondence with the domains evaluated.

The final assessment of the certainty of the evidence was judged in four levels or categories: high, moderate, low or very low. In the framework of the development of the present review, we considered global certainty to be moderate, given that, although the results showed a clear directional consistency regarding the effect of low energy availability and glycogen depletion on yield, limitations were found on the precision and generalizability of the findings as

methodological heterogeneity, reduced sample sizes and methodical variability of glycogen assessment.

2.6 METHODOLOGICAL LIMITATIONS

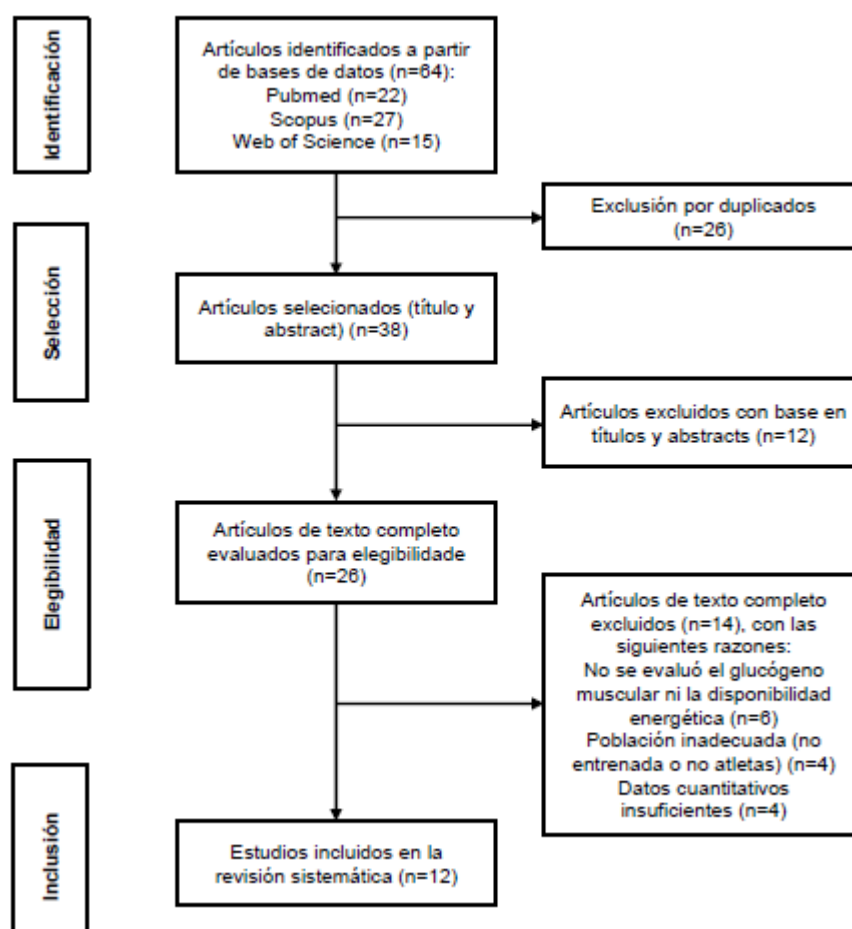
The procedures for study selection, data extraction and assessment of risk of bias were carried out by a single author, as mentioned in due course. This corresponded to the fact that the review was carried out within the framework of an academic project with limited resources. In direct relation to the latter, in order to minimize potential biases, methodological strategies were implemented in order to guarantee procedural consistency and transparency: a priori definition of the selection criteria and their systematic application in all phases of the selection process, according to the PRISMA 2020 guide (12); Reduction of the risk of missing relevant studies when identifying and screening studies through a structured and reproducible search strategy across multiple databases. The protocol of this study was not prospectively registered in international platforms such as PROSPERO, a decision that corresponded to the realization of the review within an academic project framework with exploratory scope. Notwithstanding the latter, the guarantee of methodological transparency and reproducibility derived from the a priori definition and detailed report according to the PRISMA 2020 guide (12) of the eligibility criteria, search strategies, study selection process and synthesis methods, thus seeking to maintain comparable methodological standards in terms of traceability and clarity of the review process.

3 RESULTS

Figure 1 represents the flow process derived from the application of the PRISMA 2020 criteria (12) that resulted in the inclusion of 12 studies.

Figure 1

Flowchart of the selection process and number of items included.



Source: Authors.

The characteristics and main findings of the included studies are summarized in Table 1. The included studies included experimental research, systematic reviews, and applied physiological studies with trained adult populations or athletes.

Table 1

Results of the systematic review according to PRISMA 2020 criteria

Primer author/ Year	Population	Design of Study	Glycogen method/ LEA Review	Main findings	Limitations
Vigh-Larsen 2022	Trained athletes (n=18)	Experimental, crossover	Biopsy muscle (location subcellular)	Intrafibrillary depletion ~40% → ↓ HI performance (≈8-12%)	n small

Hokken 2021	Athletes elite (n=10)	Experimental	Subcellular biopsy	↓ Neuromuscular strength with Depletion Local No total exhaustion	Does not evaluate LEA
Rountree 2017	Trained athletes (n=19)	Controlled Trial	Performance + CHO Intake	CHO intake ↑ total work 6- 12%	Short term
Wroble 2019	Trained athletes	Observational	Intake esti mated energy	Deficit Energy chronic Associate a ↓ Performanc e repeated	INDIRECT READ
Sultan 2025	Athletes Functional	Observational	Biomarkers + Performance	LEA associated with ↑ fatigue and ↓ Final Power	Design transversal
Margolis 2021	Athletes Trained	Experimental	Glycogen M uscle Indirect	Low DUDE → ↓ Resynthesis post-exercise glycogen	Does not measure total EA

Source: Authors.

The quantitative descriptive synthesis evidenced a heterogeneous availability of data on muscle glycogen and LEA, which prevented the performance of a formal meta-analysis according to the criteria of PRISMA 2020 (12). Four studies (33%) evaluated muscle glycogen directly, through muscle biopsies or analysis of its subcellular location, demonstrating that glycolytic depletion in the order of 30-40% is associated with a significant decrease in performance in high-intensity exercise, with estimated reductions of 8-15% in total work capacity and maximal force production (13,14,19,20). These effects were observed even in the absence of complete total glycogen depletion, underscoring the functional relevance of selective intrafibrillary depletion.

Five studies (42%) addressed total energy availability or its indirect estimation, identifying that values compatible with LEA, operationally defined as insufficient energy intake relative to training expenditure, were associated with consistent hormonal alterations, including reductions in leptin and T3, along with increases in cortisol, setting up a catabolic metabolic environment (2,15,16,17,18). In these studies, the presence of LEA was also associated with impaired ability to sustain repeated high-intensity efforts and increased perception of fatigue, even in the absence of significant changes in body mass.

Likewise, studies that analyzed physiological demands typical of functional sports reported sustained oxygen consumption close to 85-92% of VO_{2max} and blood lactate concentrations above 10-12 mmol/L during competition or training, which shows a high dependence on glycolytic metabolism and, therefore, on adequate muscle glycogen stores (10,11). Taken together, these quantitative findings indicate that both muscle glycogen reduction and the presence of LEA consistently compromise physical performance and resilience in high-work-density settings, although methodological heterogeneity between studies limited the possibility of integrating the results using combined statistical analyses.

Regarding the assessment of methodological quality and risk of bias of the included studies, overall, seven of the twelve studies had a low to moderate risk of bias, while the remaining five were classified as having moderate risk of bias, with no studies identified as being at critical risk of bias.

The main methodological limitations detected in the experimental studies included small sample sizes, absence of blinding of participants and investigators, and short-term follow-up, factors that may influence the accuracy of the observed effects on muscle glycogen and physical performance (13,14,19). In observational studies, the risk of bias was mainly related to the indirect measurement of energy availability, the dependence on dietary self-reports, and the cross-sectional design, which prevents establishing causal relationships between LEA and the physiological variables evaluated (2,15-18).

On the other hand, the included reviews showed a low to moderate risk of bias, conditioned by the heterogeneity of the primary studies and the absence of combined quantitative analyses in some cases (8,20). Overall, we judged the overall quality of the evidence to be moderate, with clear directional consistency in the effects of LEA and glycogen depletion on performance in functional sports, although with limitations in the precision and generalizability of results due to methodological variability between included studies.

4 DISCUSSION

The evidence gathered in this systematic review shows that energy availability and muscle glycogen status are determinants of performance and physiological adaptation in contemporary functional sports, such as CrossFit, Hyrox and hybrid training. Throughout the studies analyzed, it is observed that both glycogen depletion and LEA exert adverse effects that are manifested in the ability to maintain potency, post-exercise recovery and anabolic signaling associated with protein synthesis.

More recent physiological studies, such as that of Vigh-Larsen et al. (13), confirm that the subcellular distribution of glycogen within the muscle fiber plays a crucial role in fatigue. The reduction of up to 70% of intrafibrillary glycogen in type II fibers during intense intermittent exercise is directly related to loss of strength and decreased performance.

This finding explains why, in modalities such as CrossFit or Hyrox, even partial reductions in local glycogen stores can compromise the ability to sustain repeated high-intensity efforts. The neuromuscular fatigue observed in these disciplines is not only dependent on global glycogen depletion, but also on localized depletion in compartments critical for rapid muscle contraction.

On the other hand, studies exploring low-carbohydrate nutritional strategies or ketogenic diets (15,16) showed conflicting results, but the general trend points to a reduction in anaerobic performance and maximal power, especially in glycolysis-dependent activities. Although prolonged adaptation to diets very low in CHO can increase fat oxidation, the results suggest that these strategies compromise the ability to produce fast energy, essential in functional or competitive training. In this sense, carbohydrate periodization (training with low availability in low-intensity sessions and competing with high reserves) emerges as a useful tool, as long as it is carefully planned to avoid prolonged episodes of ALE.

Evidence on anabolic signaling and recovery reinforces the importance of maintaining adequate glycogen status. Margolis et al. (17) demonstrated that initiating exercise with low glycogen attenuates the activation of the mTORC1 pathway and reduces the expression of myogenic markers such as PAX7 and MYOGENIN. These findings are relevant in the context of functional sports, in which training frequency and high weekly workload require optimal recovery. Prolonged LEA and persistent glycogen shortages limit the ability to adapt to training, with a negative impact on both strength and protein synthesis and body composition.

Regarding the physiological axis, the studies reviewed (2,19) establish a clear relationship between LEA, glycogen depletion and hormonal alterations. Under conditions of low energy availability, a significant decrease in leptin and insulin is observed, accompanied by an increase in cortisol, which favors a catabolic environment and reduces the capacity for glycogen resynthesis. In women, these effects are more marked and can lead to menstrual dysfunctions and thyroid disorders, adding to the impact on bone density and performance. The relationship between LEA and muscle glycogen, therefore, transcends the energy aspect and becomes a central axis to understand the metabolic, hormonal and muscular adaptations of functional athletes.

Finally, the practical literature (8,11,20) provides specific guidelines for optimizing carbohydrate intake and timing in high-density sports. The "fuel for the work required" strategies fit particularly well into the logic of functional training, where the demands vary per session. Ingesting between 1.0-1.2 g/kg.h of CHO in the first hours of recovery, together with protein and fluids, is associated with optimal glycogen resynthesis and an improvement in energy availability for consecutive sessions. The study by Brandt et al. (11) provides recent evidence on Hyrox, showing that the test imposes a mixed energy demand with high glycogen dependence; Therefore, proper recharging between training rounds is critical.

Taken together, the results of this review confirm that maintaining an adequate energy balance and optimal glycogen stores is essential not only for acute performance, but also for chronic adaptation to functional training. Sustained LEA can act as a negative modulator of performance and health, particularly in women, and should be considered a metabolic and endocrine risk factor in the sports field.

5 CONCLUSIONS

The results suggest that the preservation of adequate glycogen stores is a determining factor for the athlete's performance and metabolic health. In addition, it is proposed that the evaluation of LEA in these contexts should incorporate indirect markers of glycogen availability, such as indicators of fatigue, decreased performance, slow recovery or a feeling of persistent muscle exhaustion.

From an applied perspective, this work reaffirms the importance of updating CrossFit Inc.'s nutritional recommendations and promoting evidence-based nutrition education among both athletes and coaches. The lack of specific protocols on carbohydrate intake and timing in CrossFit and hybrid modalities represents a gap that should be addressed through updated guidelines, with special emphasis on the prevention of ALS in women.

Limitations include the paucity of studies that include female CrossFit or Hyrox athletes, the predominant use of male samples, and methodological heterogeneity in glycogen assessment (biopsy, MRI, indirect estimates). However, the findings are consistent in pointing out the need to maintain an adequate energy balance and sufficient carbohydrate intake to sustain adaptations to functional training. On the other hand, a methodological limitation of this systematic review is that the process of study selection, data extraction and assessment of risk of bias was carried out by a single reviewer, which could increase the risk of selection and interpretation bias. However, this risk was mitigated through the application of a priori defined criteria and the use of validated assessment tools.

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COMMUNITY-BASED TOURISM PRACTICES IN THE COMMUNITIES OF CÓRREGO DO SAL AND BARRINHA, IN ICAPUÍ

PRÁTICAS DE TURISMO COMUNITÁRIO NAS COMUNIDADES DE CÓRREGO DO SAL E DE BARRINHA, EM ICAPUÍ

PRÁCTICAS DE TURISMO COMUNITARIO EN LAS COMUNIDADES DE CÓRREGO DO SAL Y BARRINHA, EN ICAPUÍ



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ABSTRACT

The present study aims to examine community-based tourism in the communities of Córrego do Sal and Barrinha, located in the municipality of Icapuí, with the objective of analyzing how community-based tourism is developed in these areas. Tourism encompasses various typologies, and community-based tourism is one of them. It is characterized by being developed by residents of a given region, with the objective of organizing and controlling local productivity and generating income through tourism. In this context, the article focuses on community-based tourism practices in Córrego do Sal and Barrinha, investigating experiences and local dynamics supported by partnerships such as Fundação Brasil Cidadão, Fundação AVINA, Fundação O Boticário, and Banco Santander. The methodology applied consisted of a bibliographic review, based on authors such as Coriolano, Borges, Maldonado, Mollison, Sancho, and Soares, and field research using a semi-structured questionnaire administered to the local community. Córrego do Sal and Barrinha were selected as case studies due to their tourism potential oriented toward community-based tourism. The research demonstrated that, through the practice of community-based tourism and the encouragement of local participation as both actors and entrepreneurs, the region developed initiatives such as the Mulheres Alimentando Vidas group and the Mulheres de Corpo e Alga group, which contribute to the growth of community-based tourism by generating employment and income for the local population, while also attracting tourists interested in experiencing this type of tourism that promotes the destination while preserving it. Understanding the community-based practices implemented in these communities is relevant for identifying successful models that can be adapted and promoted in other locations as a means of fostering local economic and social development, making residents the driving force behind these initiatives.

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Keywords: Tourism. Community-Based Tourism. Coastal Communities.

RESUMO

O presente trabalho busca o estudo do turismo comunitário nas comunidades de Córrego do Sal e de Barrinha, pertencentes ao município de Icapuí, tendo como objetivo estudar como se dá o turismo comunitário nestas comunidades. O turismo apresenta diversas tipologias e o turismo comunitário é uma delas. O turismo comunitário é aquele em que é desenvolvido por moradores de uma determinada região, onde se tem como objetivo a organização e o controle da produtividade local e a geração de renda através do turismo. Neste sentido, o artigo volta-se as práticas de turismo comunitário em Córrego do Sal e Barrinha, investigando-se experiências e vivências a partir do turismo local e apoio de parcerias como a Fundação Brasil Cidadão, Fundação AVINA, Fundação O Boticário e Banco Santander. A metodologia aplicada no trabalho foi pesquisa bibliográfica, através de autores como Coriolano, Borges, Maldonado, Mollison, Sancho e Soares ; e pesquisa de campo, através de um questionário semiestruturado, aplicado com a comunidade local. Córrego do Sal e Barrinha foram escolhidos como objeto de estudo por terem o potencial turístico voltado ao turismo comunitário. A pesquisa demonstrou que através da prática do turismo comunitário e incentivo da participação local como atores e empreendedores, a região desenvolveu projetos como o grupo Mulheres Alimentando Vidas e o grupo Mulheres de Corpo e Alga que influenciam no crescimento do turismo comunitário, através da geração de emprego e renda para comunidade local, além de promover atração de turistas interessados em vivenciar este tipo de turismo que promove o destino, porém que também o preserva. Conhecer as práticas comunitárias aplicadas na comunidade faz-se relevante para buscar modelos de práticas exitosas que podem ser adaptadas e impulsionadas em outras localidades, como forma de desenvolver o desenvolvimento econômico e social local, tornando os moradores os propulsores das ações.

Palavras-chave: Turismo. Turismo Comunitário. Comunidades Litorâneas.

RESUMEN

El presente trabajo tiene como objetivo estudiar el turismo comunitario en las comunidades de Córrego do Sal y Barrinha, pertenecientes al municipio de Icapuí, con el fin de analizar cómo se desarrolla el turismo comunitario en estas localidades. El turismo presenta diversas tipologías, siendo el turismo comunitario una de ellas. Este se caracteriza por ser desarrollado por los habitantes de una determinada región, con el objetivo de organizar y controlar la productividad local y generar ingresos a través del turismo. En este sentido, el artículo se centra en las prácticas de turismo comunitario en Córrego do Sal y Barrinha, investigando experiencias y dinámicas locales con el apoyo de alianzas como Fundação Brasil Cidadão, Fundação AVINA, Fundação O Boticário y Banco Santander. La metodología aplicada consistió en una revisión bibliográfica, basada en autores como Coriolano, Borges, Maldonado, Mollison, Sancho y Soares, y una investigación de campo mediante un cuestionario semiestructurado aplicado a la comunidad local. Córrego do Sal y Barrinha fueron seleccionados como objeto de estudio debido a su potencial turístico orientado al turismo comunitario. La investigación demostró que, a través de la práctica del turismo comunitario y el fomento de la participación local como actores y emprendedores, la región desarrolló iniciativas como el grupo Mujeres Alimentando Vidas y el grupo Mujeres de Cuerpo y Alga, que contribuyen al crecimiento del turismo comunitario mediante la generación de empleo e ingresos para la comunidad local, además de atraer turistas interesados en vivir este tipo de turismo que promueve el destino, pero también lo preserva. Conocer las prácticas comunitarias aplicadas en estas comunidades resulta relevante para identificar modelos exitosos que puedan ser adaptados y promovidos en otras localidades como una forma de impulsar el desarrollo económico y social local, convirtiendo a los habitantes en los principales impulsores de estas acciones.

Palabras clave: Turismo. Turismo Comunitario. Comunidades Costeras.

1 INTRODUCTION

The object of this article is the communities of Córrego do Sal and Barrinha, located in the municipality of Icapuí, in which we were able to observe how community tourism takes place and experiences resulting from projects, such as the Women Feeding Lives group and the Women of Body and Seaweed group. The communities studied have natural resources and tourist attractions, in which they influence to be recipients of local tourism.

Tourism comprises the activities carried out during free time in the form of leisure, outside its routine. These activities are for the purpose of leisure, work, adventure, among others. Tourism has several typologies and among them we find community tourism, a typology in which it aims at the organization and control of local productivity generated from tourism in a given community, becoming a more egalitarian form of income.

In this sense, community tourism has grown with the objective of strengthening and enhancing tourism experiences in communities, promoting experiences between tourists and communities. Fostering the union and articulation of communities, where residents are involved and motivated to participate in activities, ensuring a form of income generation.

On the coast of Ceará, some communities practice community tourism, such as Córrego do Sal and Barrinha, which are located in the municipality of Icapuí. In which they have natural resources and attractions that influence the quality of local life. Through articulation and union, the communities began to organize themselves and control the local productive activity, based on community tourism.

Córrego do Sal is located near the border of Ceará with Rio Grande do Norte and is known for being a region with an extensive area of salt pans in which it gave rise to its name of Córrego do Sal. In addition to having lush landscapes and enjoying natural resources such as fauna and flora, the community is also linked to agriculture and fishing.

The community of Barrinha is located on Barrinha beach, 5.3 km from the center of Icapuí. The community benefits from Barrinha beach because it has a vast algae bank, with algae cultivation and fishing as a source of income. Through its attractions, the community has become a tourist receiving center, generating employment and increasing local income.

The study focuses on the practices of community tourism carried out in the communities of Córrego do Sal and Barrinha, with the objective of studying how community tourism takes place in these communities. Investigating experiences such as the creation of groups and projects and experiences of communities from local tourism. Also investigating the results of partnerships and foundations that support communities.

In the development of this work we used bibliographic research, making queries on institutional websites regarding the subject addressed, also reading books such as Coriolano, Borges, Maldonado, Mollison, Sancho and Soares. To carry out the study, the methodology used was the qualitative approach where a field research was carried out for three days, in which interviews were made with some residents of the communities, and it was also possible to get to know the communities and the projects developed.

The research analyzes the relationship of communities with community tourism, the exchange of experiences and experiences from the insertion of local tourism. The study shows that some coastal communities began to know and work with tourism in a way that it benefits them, that is, they began to organize and articulate themselves practicing community tourism. The communities of Córrego do Sal and Barrinha resulted in the union and development of projects with the support of the Brazil Citizen Foundation, AVINA Foundation, O Boticário Foundation and Banco Santander.

2 TOURISM

Tourism is a social, economic and cultural activity that involves the displacement of people to certain places, for the purpose of leisure, work, among others. For this displacement to occur, it is necessary for people to have free time.

Tourism has several definitions, one of the most referenced is that of the World Tourism Organization – UNWTO, for Sancho apud UNWTO (2001, p. 38) "tourism comprises the activities that people carry out during their trips and stays in places other than their usual surroundings, for a consecutive period of less than one year, for leisure, business or other purposes".

The UNWTO also mentions that "any displacement outside the place of residence for a period of more than 24 hours and less than 60 days, motivated by non-economic reasons, can be understood as tourism".

This is a broad definition, in which it concretizes the most important characteristics of tourism. Which are: The motivating elements of travel, the period of time and stay, location of the tourist activity as an activity carried out, that is, outside its routine.

Tourism is segmented into several typologies, the most practiced are: Business tourism, adventure tourism, ecotourism, cultural tourism, sports tourism,

community tourism, among others. Each typology meets a different public profile, aiming to satisfy according to their interest and travel motivation.

In this way, the tourist activity moves the local market activity, causing the communities to organize themselves and be part of this tourist movement. And so the communities start to seek the strengthening of the organization as a community base, as economic activities and the growth of community tourism.

2.1 COMMUNITY TOURISM

Community tourism is developed by residents of a given place, where the objective is the organization and control of local productivity and the generation of income through tourism. According to Coriolano (2009, p.282), "Community tourism is that in which communities in an associative way organize local productive arrangements, having effective control of the land and economic activities associated with the exploitation of tourism".

Local productive arrangements are considered territorial agglomerations of economic, political, and social agents. In which it focuses on a specific set of economic activities. Concentrating on micro and small family-based subsistence enterprises producing tertiary activities for the tourism production chain.

Tourism involves a diversity of producers, such as local residents and the public administration, which ends up generating a variety of expectations in relation to its development. With the ability to articulate between them and their interests, it contributes positively to the planning of more responsible tourism in the localities.

For Maldonado (2009, p.31), community tourism:

It is understood as any form of business organization based on the ownership and sustainable self-management of community heritage resources, in accordance with the practices of cooperation and equity in labor and in the distribution of benefits generated by the provision of tourist services. The distinctive characteristic of community tourism is its human and cultural dimension, that is, anthropological, with objective of encouraging dialogue between equals and quality interim meetings with our visitors, in the perspective of knowing and learning from their respective ways of life.

Community tourism promotes the exchange of experiences between communities and tourists, which aims to ensure that the community develops the activity as a way to supplement the income of families. And so tourism can bring benefits and contribute to the consolidation of the local economic base.

This type of tourism stands out for its community organization and income generation, through local tourist attractions, creating a connection and articulation of the communities involved. Residents are involved and actively participate in discussions and activities, ensuring

a more equal distribution of income. And so it can be approached as one that is thought, developed and executed by the communities.

3 METHODOLOGY

The research aims to study the practice of community tourism in the communities of Córrego do Sal and Barrinha. For this it was necessary to research tourism, its typologies and community tourism, which was done through institutional websites, dissertation and books by Coriolano, Maldonado, Borges, Mollison, Sancho and Soares, relevant to the subject addressed. In this way, we used the bibliographic research that, According to Gil (2002), the bibliographic research is developed based on material, already prepared, consisting mainly of books and scientific articles.

To carry out the research on the communities, it was necessary to carry out a field research, where it was possible to go to the communities and conduct interviews with some residents and members of the community projects. We stayed three days in the communities and during the stay we met and interviewed the Women Feeding Lives group and the Women of Body and Seaweed group. In this way, it was possible to learn a little about the work and experiences of these residents in relation to community tourism.

The method of approach used was qualitative, which, according to Richardson (2007), can be characterized as the attempt to have a detailed understanding of the meanings and situational characteristics presented by the interviewees, instead of the production of quantitative measures of characteristics or behaviors. Qualitative research was used to understand and interpret the opinion of the residents, interview them and observe the communities.

4 COMMUNITY TOURISM IN ICAPUÍ

Community tourism is growing more and more on the coast of Ceará, turning coastal communities into tourist receiving centers. Some communities constitute different forms of tourist services, others already have their own way of life.

The tourism developed by the coastal communities of Ceará has been called community tourism because it requires the involvement of all, considers individual and collective rights and duties, and elaborates a participatory planning process, from decision-making to the execution of tourist activities. It is carried out on a human scale. It develops participatory management (...), in addition to taking into account the local culture, the appreciation of cultural heritage, and the desires and needs of the people in the communities. Community tourism is that developed

by the residents of a place who become the articulators and builders of the production chain, where income and profit remain in the community and contribute to improving the quality of life (...) (CORIOLANO, 2003, p. 41).

One of the first community tourism experiences developed in Ceará was in 1998, in the community of Prainha do Canto Verde, in Beberibe with the formation of the Tourism and Handicraft Cooperative of Prainha do Canto Verde (COOPECANTUR). From the tourism model carried out in the community, new tourism experiences were created in the coastal area of Ceará, making other communities experience with small groups to receive visitors.

Among these coastal communities is Icapuí, one of the municipalities in Ceará that practices community tourism. The municipality is located in the extreme east of the coast of Ceará, approximately 200 km from Fortaleza. With a tropical and semi-arid climate and average annual temperatures ranging from 26° to 28° C, the region of Icapuí receives tourists all year round.

The municipality of Icapuí currently has an estimated 19,418 inhabitants according to IBGE (2015). Having a territorial occupation linked to livestock and fishing activity, it stands out for its landscapes, vegetation cover and its diversity from tableland forests, mangroves, dunes, beaches and carnaubais. And through these natural resources, local tourism developed and with the articulation and mobilization of communities, community tourism began.

The municipality of Icapuí has communities such as Ponta Grossa, Tremembé, Redonda, Requenguela, Barrinha and Córrego do Sal, which practice community tourism. Ponta Grossa is one of the communities that is part of the Tucum Network, along with Requenguela and Barrinha, which benefited from the biological sanitary sewage and rainwater harvesting project, with the support of the Petrobras Environmental Program, carried out by the Brazil Citizen Foundation-FBC, which was of great importance for the communities.

And through these programs and the mobilization of communities, Barrinha and Córrego do Sal started to work on community tourism, as a way of generating income and developing local tourism.

4.1 COMMUNITY OF CÓRREGO DO SAL

The community of Córrego do Sal is located approximately 20 km from the center of Icapuí and close to the border of Ceará with Rio Grande do Norte. The origin of the name of the community is due to the fact that the region has a large area of salt pans and a stream where water passes to the present day. Hence the name "Córrego do Sal". According to the Brazil Citizen Foundation (2008), the community has 16 families and approximately 64 inhabitants.

From 1997, the Community Association of Residents was created, which collaborated for the improvement of basic services, the implementation of electricity, construction of the church, school transportation, community water well and garbage collection. Through the interrelationship and local motivation, focusing on the principles of organization, shared management and sustainability, community tourism was developed.

The Women Feeding Lives group was created by the entrepreneurial initiative of the community of Córrego do Sal, having emerged from the understanding and sensitization of the women of the community, who work through the Community Kitchen, which serves tourists and local residents and is located under a cashew tree, being known as an open kitchen according to Francineide (member of the group and resident, 2015), the food is prepared in clay pots and on the wood stove.

The women of the group grow vegetables and vegetables in an organic and sustainable way for local consumption and commerce, giving rise to the community garden. The organic ingredients that come from the community garden are used in the preparation of the food made by the group in order to enhance its flavors. The group also had the support of Banco Santander's Partnerships in Action Program.

Fishing is also one of the practices carried out by the community as a source of economy and local consumption, especially lobster. Lobster fishing began in 1957 in the municipality of Icapuí, generating income for the municipality through export and commercialization.

The place draws attention for its natural beauty, its hospitality and tranquility and also for its diversified gastronomy, with typical dishes of the region such as shellfish stews, shrimp bobó and galinhada. In addition, the community sells vegetables from the community garden and honey from the native Jandaíra stingless bee.

In this way, community tourism begins to expand in Córrego do Sal, through the natural resources of the region, the cultivation of food and fishing. The community begins to offer and enjoy its tourist attractions, strengthening the community organization, generating income and moving local economic activity.

4.2 COMMUNITY OF BARRINHA

Barrinha is one of the communities in Icapuí that practices community tourism. Located 5.3 km from the center of Icapuí, the community is located on Barrinha beach, municipality of Icapuí. Community which is formed by residents who survive from fishing and alginoculture (algae cultivation).

The community is located on Barrinha beach, which has natural resources such as the cultivation of seaweed and the fishing of fish and seafood, which are used for consumption and trade. Barrinha beach has a vast bank of seaweed of the species *Gracilaria* sp, which is of great importance for commercialization because it is used both in cosmetics and for food.

Alginoculture is an activity that generates economic, social and environmental benefits for the community. With alginoculture, the community started to sell seaweed and generate income. Socially, seaweed cultivation contributed to the improvement of family income, with the growth and strengthening of communities through the interaction and union of all.

The algae are cultivated in a sustainable way, where they are planted on ropes in the sea and after fifteen days maintenance is carried out, removing mollusks that end up preventing their growth, after ninety days the harvest is done and the drying process begins. In this way, the community started to use this method in a sustainable way, which benefits both it for being a source of income, and the fauna for the way of cultivation and maintenance of algae, contributing to local development and consequently, the community, because through this cultivation it was possible to recover local biodiversity, avoid predatory collection and the possible extinction of algae, ensuring the activity carried out.

From alginoculture, the "Women of Body and Seaweed" project was created, formed by women from the community, who participate in the cultivation of algae and the extraction process of Agar-agar (hydrocolloid from red algae) which is used in the manufacture of cosmetics such as shampoo, soap and some types of food such as mousses, pancakes and jellies, Agar-agar is also sold in the form of powdered flour.

Figure 1

Algae cultivation on Barrinha beach Source: Brazil Citizen Foundation, 2012



The project was supported by the Brazil Citizen Foundation, which helped in the construction of the laboratory kitchen, where they prepare and produce their products, taught them how to manufacture cosmetics and food with higher quality and recyclable packaging. The group also had the support of the O Boticário Foundation and the AVINA Foundation, which invested in training, awareness about sustainable exploration and cultivation, notions in permaculture and bioconstruction, also providing equipment.

Permaculture is a system that promotes the integration of animals and plants with human beings. According to Molisson, permaculture is: "Consciously designed landscapes that reproduce patterns and relationships found in nature and that, at the same time, produce food, fiber and energy in abundance and sufficient to provide for local needs."

Bioconstruction is an important element for permaculture, as it seeks integration between buildings and their environment. It seeks to plan and execute using available resources with less impact and ecologically, and can also be called self-construction techniques.

The concept of bioconstruction for Soares (1998):

It encompasses several techniques of world vernacular architecture, some of them with hundreds of years of history and experience, characterized by the preference for local materials, such as earth, reducing expenses with manufacturing and transportation and building low-cost housing that offers excellent thermal comfort.

In this way, the group of women who are part of the project began to be trained and instructed to develop the project in a sustainable way and with quality products, also taking advantage of the algae extract that is discarded during the manufacturing process of the products, for the manufacture of biofertilizers (algae-based fertilizers) and biodiesel.

5 FINAL CONSIDERATIONS

The purpose of this work was to present how community tourism is developed in Córrego do Sal and Barrinha, which are communities in the municipality of Icapuí. During the work we approached tourism and community tourism to understand a little about the subject and then understand community tourism in Icapuí. Based on community tourism we realized that the communities began to organize themselves and learn new ways of working with community tourism, such as working tourism in a sustainable way, improving the working methods used by the residents conserving the local biodiversity.

In this sense, the community of Córrego do Sal presented improvements through the collaboration of the Community Association of Residents, such as the implementation of electricity and basic infrastructure services, making tourism in the region and economic growth

possible. The group of women in the community presented improvements and motivation from the support and encouragement of the community and the Brazil Citizen Foundation.

The community of Barrinha has natural resources that favor the practice of community tourism. We observed that the community lives from fishing and alginoculture, practiced in a sustainable way to maintain biodiversity and guarantee local income. The "Women of Body and Seaweed" project showed the determination of women in alginoculture, valuing the resources that the community offers and moving local activity.

The communities presented were chosen because they have a tourist potential focused on community tourism, aiming at the growth and recognition of the communities. They are coastal communities that enjoy the natural attractions and preserve the ecosystem, ensuring an improvement in the quality of life. The sustainable way of working brought a great result to the community of Barrinha, as the sustainable cultivation of algae meant that the algae bank did not reach a possible extinction.

In short, community tourism has allowed communities to show their identity without losing their origins and culture. In addition to favoring the growth of local tourist activity, in which it has aroused the interest of partnerships and foundations

encouraging the creation of projects and work in a sustainable way. Therefore, community tourism has promoted a differentiated tourist activity, in which both communities and tourists can enjoy the resources offered.

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INTELLIGENT ARCHITECTURES FOR SUSTAINABLE HOUSING: USE OF AI IN THE MANAGEMENT AND STORAGE OF RENEWABLE ENERGY

ARQUITETURAS INTELIGENTES PARA HABITAÇÕES SUSTENTÁVEIS: USO DE IA NA GESTÃO E ARMAZENAMENTO DE ENERGIA RENOVÁVEL

ARQUITECTURAS INTELIGENTES PARA VIVIENDAS SOSTENIBLES: USO DE IA EN LA GESTIÓN Y ALMACENAMIENTO DE ENERGÍA RENOVABLE



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ABSTRACT

The growing integration between digital technologies and renewable energy sources has redefined how energy consumption is organized in residential environments, especially in the context of sustainable housing. The present study aims to analyze how intelligent architectures based on artificial intelligence can optimize the management and storage of renewable energy in sustainable housing, aiming at greater energy efficiency and residential autonomy. Regarding the research design, a qualitative approach was adopted, guided by the interpretative analysis

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of data from multiple sources. This methodological choice allows for examining the investigated phenomenon in greater detail, considering not only the data itself but also the contexts in which they are embedded and the meanings associated with the analyzed technologies. By articulating theoretical and documentary information, it becomes possible to develop a consistent analysis capable of integrating different perspectives and expanding the understanding of the topic in a more comprehensive and contextualized manner. In summary, the research demonstrated that the integration of intelligent architectures, artificial intelligence, and energy storage systems contributes to the development of more efficient and autonomous housing by enabling more precise and adaptive energy management. The articulation of these technologies promotes the rational use of renewable sources and fosters greater balance in residential energy consumption, consolidating a housing model aligned with current demands for efficiency and sustainability.

Keywords: Intelligent Architectures. Artificial Intelligence. Renewable Energy. Energy Efficiency.

RESUMO

A crescente integração entre tecnologias digitais e fontes de energia renovável tem redefinido o modo como o consumo energético é organizado em ambientes residenciais, especialmente no contexto das habitações sustentáveis. O presente estudo tem como objetivo geral analisar como arquiteturas inteligentes baseadas em inteligência artificial podem otimizar a gestão e o armazenamento de energia renovável em habitações sustentáveis, visando maior eficiência energética e autonomia residencial. No que se refere à condução da pesquisa, adotou-se uma abordagem qualitativa, orientada pela análise interpretativa de dados provenientes de múltiplas fontes. Essa escolha metodológica permite examinar o fenômeno investigado com maior nível de detalhe, considerando não apenas os dados em si, mas também os contextos em que estão inseridos e os significados associados às tecnologias analisadas. Ao articular informações de natureza teórica e documental, torna-se possível desenvolver uma análise consistente, capaz de integrar diferentes perspectivas e ampliar a compreensão do tema de forma mais abrangente e contextualizada. Em síntese, a pesquisa demonstrou que a integração entre arquiteturas inteligentes, inteligência artificial e sistemas de armazenamento de energia contribui para a construção de habitações mais eficientes e autônomas, ao permitir uma gestão energética mais precisa e adaptativa. A articulação entre essas tecnologias favorece o uso racional de fontes renováveis e promove maior equilíbrio no consumo energético residencial, consolidando um modelo de habitação alinhado às demandas atuais por eficiência e sustentabilidade.

Palavras-chave: Arquiteturas Inteligentes. Inteligência Artificial. Energia Renovável. Eficiência Energética.

RESUMEN

La creciente integración entre tecnologías digitales y fuentes de energía renovable ha redefinido la forma en que se organiza el consumo energético en entornos residenciales, especialmente en el contexto de viviendas sostenibles. El presente estudio tiene como objetivo analizar cómo las arquitecturas inteligentes basadas en inteligencia artificial pueden optimizar la gestión y el almacenamiento de energía renovable en viviendas sostenibles, con el fin de lograr una mayor eficiencia energética y autonomía residencial. En cuanto al desarrollo de la investigación, se adoptó un enfoque cualitativo, orientado por el análisis interpretativo de datos provenientes de múltiples fuentes. Esta elección metodológica permite examinar el fenómeno investigado con mayor nivel de detalle, considerando no solo los datos en sí, sino también los contextos en los que se insertan y los significados asociados a las tecnologías analizadas. Al

articular información de carácter teórico y documental, se posibilita desarrollar un análisis consistente, capaz de integrar diferentes perspectivas y ampliar la comprensión del tema de manera más amplia y contextualizada. En síntesis, la investigación demostró que la integración entre arquitecturas inteligentes, inteligencia artificial y sistemas de almacenamiento de energía contribuye a la construcción de viviendas más eficientes y autónomas, al permitir una gestión energética más precisa y adaptativa. La articulación de estas tecnologías favorece el uso racional de fuentes renovables y promueve un mayor equilibrio en el consumo energético residencial, consolidando un modelo de vivienda alineado con las demandas actuales de eficiencia y sostenibilidad.

Palabras clave: Arquitecturas Inteligentes. Inteligencia Artificial. Energía Renovable. Eficiencia Energética.

1 INTRODUCTION

The integration and adoption of digital technologies in the electricity sector are promoting profound transformations in the way energy is generated, distributed, and consumed. This revolution stands out especially among homes that seek to be sustainable and environmentally friendly. Technological innovations have not only transformed production, but also the way energy is delivered to consumers and how they use it in their homes. In this scenario, the combination of renewable energy sources, cutting-edge automation systems, and data analysis tools has been essential to develop residential models that are much more efficient. These domestic consumption models allow for a constant and dynamic visualization and adjustment of energy consumption, which enables a more efficient management of available energy resources. This interaction that we are witnessing today is a clear reflection of the growing convergence between technological innovation and sustainability, which, in turn, is closely linked to the incessant search for solutions that minimize harmful effects on the environment. In addition, this guideline also covers energy autonomy, highlighting the urgency of developing alternatives that not only reduce environmental impact, but also increase independence from traditional energy sources. Therefore, it is clear that there is a strong connection between these areas, which are becoming more complementary than ever in today's world.

At the same time, the incessant advancement of artificial intelligence has significantly expanded the possibilities of energy management in residential environments, allowing intelligent systems to be able to analyze and understand energy consumption patterns, predict future demands, and adjust in real time efficiently and effectively. This enables a more efficient and sustainable management of available energy resources. Connected to innovations in energy storage, this strategy enables a more balanced and efficient use of renewable sources, especially because they are intermittent and change throughout the day and year. Thus, it seeks to maximize the use of these sustainable sources, taking into account the conditions and characteristics that can influence their generation. In this way, architectures that fit the definition of smart start to play an important role in the organization of energy flows, contributing decisively to greater efficiency and stability of energy consumption in the residential context.

In view of the panorama exposed above, this work proposes, as a general objective, to analyze how smart architectures based on artificial intelligence can optimize the management and storage of renewable energy in sustainable housing, aiming at greater energy efficiency and home autonomy. The specific objectives are as follows: Understand the fundamentals of smart architectures applied to sustainable housing using renewable energy; Analyze the role of artificial intelligence in managing consumption and optimizing the use of renewable energy in

homes; Evaluate renewable energy storage technologies and strategies in smart homes and their impacts on energy efficiency.

As for how to conduct the research, the present study uses a qualitative approach methodology, which is guided by the analytical interpretation of data obtained from several different sources. This approach provides a more detailed and deeper understanding of the phenomenon in question, allowing a broader interpretation of the data collected. This specific approach allows for a more detailed examination of the research object, considering not only the relationships it establishes, but also the contexts and meanings associated with the various technologies under study. Thus, it is possible to achieve a deeper and broader understanding of the topic under discussion. It is possible to elaborate a consistent analysis by gathering theoretical and documentary information, which allows for the articulation of different perspectives on the topic in question. This perspective adds to the understanding of the subject, allowing for a more detailed and complete conversation.

Finally, this study was organized into four sections, so that the topic can be presented in a clear and coherent way. The introduction, which clearly and objectively brings both the contextualization of the topic in question and the objectives that guide the development of this study, is in the first section of the document. Next, the section that deals with the methodology clarifies in detail the various procedures that were adopted and applied during the execution of the research. The third part of the work, which is intended for the theoretical foundation, deals with and discusses the most important concepts, as well as the various approaches that are closely connected to the topic in question. This section is vital for a deeper understanding of the main arguments that support the discussion. Finally, the final considerations serve to clearly and directly summarize the results obtained throughout the research and to indicate possibilities and potential trajectories for future investigations to be carried out, thus contributing to the advancement of the field of study in question.

2 METHODOLOGY

The increased use of smart architectures in homes that value sustainability, especially with regard to artificial intelligence aimed at the management and storage of renewable energy, reflects a profound and continuous change in the design and operation of the energy systems that power homes. This change is not only a technological step, but also a new way of seeking more conscious and efficient energy consumption in homes. It is precisely in this aspect that it becomes even more crucial, especially in the current context, where there is an urgent need to increase energy efficiency and reduce dependence on conventional energy sources. In addition,

this strategy also facilitates the increase of autonomy in relation to energy consumption in homes. In view of this, investigating the relationship between digital technologies, storage systems, and renewable energy sources enables a deeper and more organized understanding of the various paths that are being adopted for homes to become more adaptable and energetically balanced. Therefore, it is possible to see how these interactions favor a more sustainable development of the environments in which we live.

Therefore, the methodology that was selected and is being applied in this context is classified as qualitative. This is because this type of approach focuses especially on the interpretation and detailed analysis of data that are collected from various theoretical and documentary sources. This approach seeks to understand, in depth, the particularities and subtleties of the data, enabling a richer and more detailed perspective on the object of analysis. Pereira et al. (2018) state that, when it comes to phenomena that have greater complexity, qualitative research is more effective for understanding, as it considers not only the meanings, but also the relationships and contexts in which these phenomena are inserted. This allows for more detailed analyses adapted to the particularities of each case. In addition, Sousa and Santos (2020) highlight that the approach presented is very favorable to the construction of scientific knowledge, as it allows the exploration of multiple dimensions of the phenomena under analysis. This is particularly pertinent in investigations that address technological innovation and the intricate dynamics of energy.

In order for this study to be carried out and move forward, two research methods were used, which are bibliographic review and documentary research. The first, bibliographic review, is a thorough research of the existing literature on the subject; the second, documentary research, refers to the collection and analysis of documents that are pertinent and relevant to the subject in question. Thus, these procedures proved to be essential to support and improve the work carried out. The bibliographic review is fundamental for the organization and systematization of knowledge already produced scientifically, allowing the identification of a variety of concepts, theoretical models, and approaches that have been consolidated and debated in the specialized literature. In this way, it becomes an indispensable resource to understand the state of the art in a specific area of knowledge. As stated by Pereira et al. (2018), this type of survey is essential for the construction of a consistent and coherent theoretical base, as it brings together and carefully analyzes various contributions from different research and studies on the subject. The literature review found in the work presented here was meticulously elaborated, based on the extensive analysis of a variety of sources, which include not only theses and monographs, but also scientific articles that have been published in academic

events, as well as those published in journals dedicated to scientific research. Books that deal with the subject in a specialized way were also taken into account.

Desk research is crucial to help evaluate information from institutional and technical sources, which reveal practical applications and valuable guidance for the energy sector. Therefore, this focus enables a deeper understanding of the rules that govern this essential segment of the economy. Pereira and Oliveira (2024) emphasize the relevance of this procedure, as it allows the examination of documents that record practices, policies, and technological solutions. This analysis also significantly expands the understanding of the object of study. Therefore, several documents that were made available by various companies and organizations in the sector were analyzed, such as BYD Company Limited, in relation to the year 2024, in addition to Contemporary Amperex Technology Co. These documents were indispensable for the analysis that was proposed. Limited produced, in 2024, documents and reports that, like those of the International Energy Agency, published in 2023, and those of the Tesla company, also from 2024, as well as Reddy's work, which is scheduled for publication in 2025, offer important information and guidelines on the various types of energy storage systems and their numerous practical applications in the contemporary world.

The joint adoption of the literature review and documentary research proved to be adequate to the purpose of the investigation, as it allowed the articulation of theoretical foundations with practical evidence from the energy sector. The articulation between these two research procedures proved to be decisive for a broader understanding of the complexities and particularities of this field of research, allowing the construction of knowledge that encompasses both established concepts and observable realities. The method used here was what is usually called mixed research, which in this case allowed for a more consistent and integrated analysis of the subject, because it combined academic reflection, which provides the theoretical basis, with data and information from real situations and contexts of practical application. This union between theory and practice is essential for a deeper understanding of the topic in question. With this, it became possible to develop a much broader understanding of the application of artificial intelligence and storage systems in the context of sustainable homes. This gave a superior rigor and coherence to the research carried out.

3 THEORETICAL FOUNDATION

The theoretical foundation was structured in order to contemplate, in an articulated way, the main axes that support the analysis proposed in this research. To this end, it was organized into three complementary topics, which dialogue with each other and allow a progressive

understanding of the investigated phenomenon. The first topic, 3.1 Smart architectures and integration of renewable energies in residential environments, addresses the technological foundations and integration models between digital systems and renewable sources. Next, topic 3.2 Artificial intelligence applied to residential energy management examines the role of algorithms in monitoring, predicting and adjusting energy consumption in real time. Finally, topic 3.3 Energy storage systems and efficiency in sustainable housing discusses storage technologies and their implications for energy autonomy and stability. This organization favors a chained approach, in which concepts are presented progressively, allowing greater coherence in the analysis of the object of study.

3.1 SMART ARCHITECTURES AND INTEGRATION OF RENEWABLE ENERGIES IN RESIDENTIAL ENVIRONMENTS

The interconnection between digital technologies, distributed energy systems, and home automation is what distinguishes the debate on smart architectures aimed at sustainable homes. From this point on, the integration of renewable sources, notably photovoltaic systems, is managed by computational platforms that supervise, examine, and adjust energy consumption in real time. As Silva and Dias (2025) point out, the incorporation of web technologies in energy management amplifies control and enables the development of more effective models, since it favors continuous communication between devices, users, and management systems.

The literature indicates that energy management systems in smart homes have evolved from autonomous systems to user-oriented systems, in which artificial intelligence is essential for the automation of deliberations. As reported by Wang et al. (2021), such systems are developed to apprehend consumption patterns, anticipate demands, and adjust energy use based on environmental and behavioral variables. Such a strategy benefits management that adjusts more efficiently to the concrete demands of residents, reducing waste and optimizing the overall energy performance of the building.

The incorporation of Internet of Things (IoT) devices in homes has enabled the formation of smart energy centers, in which multiple sources and storage systems operate in coordination. According to El-Afifi et al. (2024), such hubs work with sensory devices, algorithms, and digital platforms to optimize, in real time, energy flows, always aiming at a balance between generation, consumption, and storage. As Yun, Nam, and Baek (2018) indicate, integrated automation also favors increased autonomy in relation to energy, as it enables agile responses to changes in the availability of renewable sources.

In this sense, Table 1 is presented, which systematizes the main components and models of technological integration in intelligent architectures aimed at sustainable housing.

Table 1

Components and integration models in smart architectures for sustainable housing

Element	Description	Role in energy management
Smart sensors	Devices that monitor variables such as temperature, luminosity, and consumption	Real-time data collection to support decision-making
Internet of Things (IoT)	Network of connected devices that communicate with each other	Integration and automation of residential systems
Photovoltaic systems	Solar panels for electricity generation	Renewable energy production at home
Storage Systems	Batteries and energy storage technologies	Storage of surpluses for later use
Artificial Intelligence	Data learning and analysis algorithms	Consumption optimization and demand forecasting
Smart energy hubs	Integrative platforms from multiple sources and devices	Coordination of energy flows
Home Automation Systems	Automated Equipment Control Technologies	Dynamic adjustment of energy consumption

Source: Adapted from Silva and Dias (2025); El-Afifi et al. (2024); Wang et al. (2021); Yun, Nam and Baek (2018).

The buildings mentioned are completely aligned with the principles of bioclimatic design, which uses the climatic and environmental characteristics of the site to increase the energy efficiency of buildings. Thus, it seeks to promote a more conscious and rational use of available natural resources, in favor of a more sustainable construction that respects the environment. According to Oliveira et al. (2021), there are a number of strategies that can be employed to reduce the need for energy consumption in buildings. Among these strategies are natural ventilation, which ensures air circulation; solar orientation, which makes the most of sunlight during the day; and the choice of suitable materials, which are selected according to their thermal properties and energy efficiency. Technology reduces the demand for energy and works together with intelligent systems that work in harmony to maximize energy efficiency. In this way, the link between passive solutions and automatic systems significantly increases the efficiency of sustainable homes, promoting a harmonious integration between what is constructive and what is technological, in a synergistic and cohesive way.

Thus, the idealization of the so-called house of the future needs to be seen in an integrated way, aligning innovation, sustainability, and quality of life. It is, therefore, essential that these three aspects are intertwined in a synergistic way in the planning and implementation of housing developments that aim not only at well-being, but also at sustainability and innovation. According to Vassão et al. (2024), digital technology in the construction industry

profoundly transforms the way internal spaces of homes are planned, structured, and experienced by their inhabitants. This concept brings homes that, in addition to adaptability, take particular care with the rhythms and needs of their residents, creating a housing experience that connects all the time to technology. In this way, the so-called smart architectures have been designed to integrate energy efficiency, home automation, and effective management of the resources consumed, creating a new housing standard that better adapts to current requirements. This type of planning aims not only to save energy, but also to create a more sustainable and efficient space for its residents, in line with the needs and challenges of contemporary life.

3.2 ARTIFICIAL INTELLIGENCE APPLIED TO RESIDENTIAL ENERGY MANAGEMENT

The adoption of artificial intelligence in household energy management has proven to be an efficient approach to monitoring and regulating energy use in homes. In Brazil, Sousa and Soares (2025) indicate that the use of intelligent systems provides a more effective management of the energy matrix, by integrating real-time data and simplifying automated decision-making. This is a paradigm shift, moving from a reactive approach to predictive management, in which consumption is monitored in real time and adjusted to the conditions of use, as well as the availability of energy resources.

In this context, machine learning algorithms play a significant role in making it possible to identify consumption patterns and predict future energy needs. As Costa (2024) points out, artificial intelligence, when incorporated into electrical systems, provides more effective management, allowing the anticipation of demand peaks and the redistribution of loads more efficiently. Such aptitude in sustainable homes provides a more effective use of renewable sources, especially when combined with storage systems that require meticulous planning to improve their performance.

The integration of artificial intelligence with Internet of Things devices amplifies the possibilities of energy management in an automated way. As Ulla et al. (2025) point out, alternatives based on Green IoT employ intelligent algorithms to coordinate appliances in a home, promoting energy savings and offering more efficient control over consumption. Similarly, Nikpour et al. (2024) indicate that systems based on the Internet of Things, combined with advanced analytical methodologies, are capable of managing the complexity of systems, adjusting the flow of energy according to several variables. As Santos and Tateoki (2024) point out, such applications enable optimized consumption in real time, harmonizing operational efficiency with sustainability. In view of these contributions, Table 2 is presented, which

organizes the main mechanisms of action of artificial intelligence in residential energy management.

Table 2

Applications of artificial intelligence in the management of residential energy consumption

Application	Description	Impact on energy management
Real-time monitoring	Continuous collection of consumption data through sensors and meters	Increased visibility and control of energy use
Demand forecasting	Use of algorithms to anticipate consumption patterns	Efficient planning of energy use and storage
Optimisation of consumption	Automatic adjustment of the operation of home devices	Reduction of waste and better energy use
IoT integration	Communication between networked devices	Intelligent coordination of residential systems
Machine learning	Historical data analysis for continuous improvement	Adaptation of the system to the users' routines
Renewable energy management	Control of the use of sources such as solar and wind	More efficient use of available sources
Smart Home Automation	Automated control of equipment and systems	Rapid responses to consumption variations

Source: Adapted from Sousa and Soares (2025); Costa (2024); Ulla et al. (2025); Nikpour et al. (2024); Santos and Tateoki (2024).

The integration and consolidation of these various technological applications clearly shows a considerable transformation in the way energy is administered and managed within the residential environment. This change reflects a new approach, making evident the evolution of the methods used for the control and efficient use of energy in homes. Artificial intelligence technology offers the ability not only to observe and monitor accurately, but also to interpret and analyze data constantly over time. This results in automatic adjustments that are implemented in the systems, making it possible to reduce waste and, at the same time, promoting a significant improvement in the overall performance of energy-oriented systems. This procedure plays a significant role in the creation of homes that are more autonomous, in which the management of resource consumption is carried out in an integrated manner, in addition to being in accordance with the real conditions of use. In this way, a new housing standard is promoted that prioritizes efficiency and adaptation to the daily lives of its users (Sousa; Soares, 2025).

In summary, the use of artificial intelligence in energy management in homes indicates significant progress in the search for greater efficiency, as well as a more rational and conscious approach to energy consumption. This innovation has shown promise, as it enables the optimization of energy use, minimizing waste and contributing to more sustainable and responsible consumption. Through the efficient combination of monitoring, forecasting, and

automation, these technological innovations provide support that enables a more equitable and harmonious use of renewable energy sources. This support is essential, as it contributes to strengthening the energy autonomy of homes, thus ensuring greater independence with regard to energy consumption. In this scenario, the convergence between intelligent algorithms and technological infrastructure redefines the dynamics of residential consumption, establishing more solid foundations for sustainability in the energy sector (Costa, 2024).

3.3 ENERGY STORAGE SYSTEMS AND EFFICIENCY IN SUSTAINABLE HOUSING

Energy storage systems occupy a central position in the consolidation of sustainable housing, especially when integrated with intermittent renewable sources. Vian et al. (2021) explain that these technologies allow balancing the relationship between generation and consumption, by storing energy surpluses for later use. This mechanism reduces dependence on the conventional electricity grid and contributes to greater stability in energy supply in residential environments.

In the context of distribution networks with high penetration of renewable sources, Almeida (2024) observes that the performance of storage systems is directly associated with the ability to respond to variations in energy generation. In smart homes, this characteristic translates into the possibility of maintaining adequate levels of supply even in periods of low generation, such as on cloudy days in the case of solar energy. Thus, storage acts as an element of energy compensation and balance.

The efficient allocation of these systems is also a relevant factor for the overall performance of networks and consumer units. Morais Filho (2020) highlights that the strategic insertion of storage devices in distribution networks allows for improved operational indicators and reduced losses. On a residential scale, this logic applies to the integration between batteries and distributed generation systems, favoring the more efficient use of locally produced energy.

In addition, storage systems play an important role in supporting the energy transition and sustainability. Ramos et al. (2026) argue that these technologies make it possible to expand the use of clean sources by mitigating problems associated with intermittency. In sustainable housing, this function is reflected in the expansion of energy autonomy, since the user becomes less dependent on external sources and can better manage their consumption.

In the technological field, different solutions have been developed by companies specializing in the sector. BYD Company Limited (2024) presents high-capacity battery-based storage systems, aimed at both residential and commercial applications. These solutions seek

to meet the demand for reliability and efficiency by integrating with photovoltaic systems and energy management platforms.

Similarly, Contemporary Amperex Technology Co. Limited (CATL) (2024) invests in the development of advanced storage technologies, with a focus on durability and operational safety. These systems are designed to operate in an integrated manner with smart grids, allowing greater flexibility in energy management and contributing to the balance between supply and demand in connected environments.

The International Energy Agency (2023) points out that the advancement of storage technologies has driven the adoption of more sustainable energy solutions on a global scale. According to the agency, storage plays a strategic role in the integration of renewable energies, by enabling greater control over generation variability. This scenario reinforces the importance of these technologies in the context of smart homes.

In the residential applications segment, Tesla (2024) develops storage systems aimed at integration with solar generation, allowing users to store energy for use at times of greater demand. These solutions contribute to the stability of the home system and expand the ability to manage energy consumption, aligning technology and sustainability.

Finally, the energy storage systems company, Reddy (2025), emphasizes that such systems face challenges related to costs, efficiency, and scalability, but continue to advance as part of the energy transition process. In sustainable housing, the adoption of these technologies represents a consistent strategy to improve energy efficiency and ensure greater autonomy, consolidating a more balanced consumption model adapted to contemporary demands.

4 FINAL CONSIDERATIONS

The focus of smart architectures applied to sustainable housing, especially with regard to the use of artificial intelligence in the management and storage of renewable energies, is within a context of significant technological and energy changes. These innovations have offered a new vision of how energy is produced, distributed, and consumed in the home, allowing a major transformation in the way energy is consumed and managed in the residential sector. The constant and growing integration between the various digital systems, along with the use of renewable sources and the adoption of solutions for energy storage, has been crucial for the creation of housing models that are more efficient and sustainable. In these new housing formats, automation is essential, because, combined with detailed data analysis, it allows for much more precise and conscious control over energy consumption habits. This also ensures

a more efficient use of available energy resources, improving the management of energy consumption in each home.

Throughout the research, it was possible to verify that the overall objective was successfully achieved. It was possible to make an in-depth study of how smart architectures, based on artificial intelligence principles, can optimize the management and storage of renewable energy in sustainable homes. In addition to increasing energy efficiency, this optimization also plays a crucial role in increasing autonomy in residential contexts. Similarly, the specific objectives that were proposed were achieved satisfactorily, as an understanding was obtained about the essential concepts that guide smart architectures, which aim to implement sustainable housing with the use of renewable energies. An in-depth analysis of the relevance and role of artificial intelligence in supervising energy consumption and optimizing energy use in contemporary homes was also carried out. A detailed evaluation of the various technologies available was carried out, along with the strategies for the storage of renewable energy in smart homes, considering how these innovations affect energy efficiency in general.

Regarding the topic discussed in item 3.1, which focuses on smart architectures and the integration of renewable energy sources in the domestic environment, the research revealed that the interaction between interconnected devices, photovoltaic solar energy generation systems and energy management platforms enables the formation of environments that dynamically adjust to variations in energy consumption and generation. It was observed that these architectures favor the automation of various processes and increase the capacity for real-time monitoring of operations, culminating in energy management that adapts more efficiently to the operational requirements of the residential system. This adaptability is essential to improve energy consumption and efficiency, as it enables more detailed control and a quick reaction to any changes in day-to-day activities at home.

With regard to sub-item 3.2, which addresses artificial intelligence in the management of energy consumption in homes, it was noted that artificial intelligence algorithms play a crucial role, as they are essential for forecasting energy demand and effectively help in identifying consumption patterns. In addition, these algorithms are essential for automating decision-making, enabling more efficient and intelligent management of energy consumption in homes. The research pointed out that these systems are capable of constantly changing the way energy is used, resulting in more efficient consumption. In addition, this strategy minimizes the losses often associated with improper use of available energy resources. This effect is especially notable when these systems are combined with interconnected devices and home automation systems, as this integration further enhances their effectiveness and the benefits they provide.

In the midst of the analysis of topic 3.3, which deals with energy storage systems and efficiency in sustainable housing, it was observed that the addition of batteries to hybrid systems is crucial to ensure a more stable energy supply. In addition, these systems are essential to considerably increase the autonomy of homes, allowing them to operate more independently and sustainably. Energy storage has proven to be a very significant and efficient solution to face the intermittency of renewable energy sources. This is because this technology allows the energy that has been accumulated in times of low demand to be released when demand increases or when generation is not sufficient. In this way, this practice leads to a notable increase in the balance between the energy available and that which is consumed.

For future research, it is suggested that empirical investigations be conducted to examine in more detail the practical implementation of these technologies in different types of homes. In this sense, it is essential to take into account relevant variables such as the cost, the accessibility of the technologies to the general public, and the performance that these technologies will show during prolonged use. With this, it is intended to achieve results that can enrich the understanding of the effect of these innovations in various home contexts. It is equally pertinent and appropriate to carefully examine how artificial intelligence relates to innovations in data storage systems. Nor can we ignore the regulatory effects and social consequences that may arise from the large-scale adoption of these technologies. This examination would enable a deeper understanding of the feasibility and use of these tools in the current energy scenario.

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INVESTIGATING THE VENEZUELAN HUMANITARIAN AND MIGRATORY CRISIS: AN FMEA AND ETA ANALYSIS VIA MULTIPLE REGRESSION

INVESTIGANDO A CRISE HUMANITÁRIA E MIGRATÓRIA VENEZUELANA: UMA ANÁLISE DE FMEA E ETA VIA REGRESSÃO MÚLTIPLA

INVESTIGANDO LA CRISIS HUMANITARIA Y MIGRATORIA VENEZOLANA: UN ANÁLISIS DE FMEA Y ETA MEDIANTE REGRESIÓN MÚLTIPLE



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ABSTRACT

This article addresses the migratory and humanitarian crisis in Venezuela, focusing on the analysis of the economic and social roots of this complex phenomenon. To comprehensively understand and approach the crisis, the Failure Mode and Effects Analysis (FMEA) and Event Tree Analysis (ETA) methodologies were applied, with results compared to those generated by two Artificial Intelligences (AI): Google Bard and ChatGPT. Additionally, the study employed a robust multiple regression econometric model to investigate the impact of socioeconomic variables on Venezuelan net migration from 1998 to 2022. The findings revealed that factors such as inflation, gross debt, oil production, and mortality rate played significant roles in the observed mass migration. These conclusions are essential for understanding the underlying economic dynamics of the crisis and may contribute to the development of more effective and sustainable policies to address it.

Keywords: Migration. Venezuela. Inflation. Artificial Intelligence. FMEA.

RESUMO

Este artigo aborda a crise migratória e humanitária na Venezuela, com foco na análise das raízes econômicas e sociais desse fenômeno complexo. Para entender e abordar a crise de maneira abrangente, foram aplicadas a Análise de Modo e Efeito de Falha (FMEA) e a Análise de Árvore de Eventos (ETA), com resultados comparáveis ao de duas Inteligências Artificiais (IA), o Google Bard e o Chat GPT. Adicionalmente, o artigo empregou um modelo econométrico de regressão múltipla robusto para investigar o impacto das variáveis socioeconômicas na migração líquida venezuelana ao longo do período de 1998 a 2022. Os resultados revelaram

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que fatores como inflação, dívida bruta, produção petrolífera e taxa de mortalidade desempenharam papéis significativos na migração em massa observada. Essas conclusões são essenciais para a compreensão das dinâmicas econômicas subjacentes à crise e podem contribuir para o desenvolvimento de políticas mais eficazes e sustentáveis para enfrentá-la.

Palavras-chave: Migração. Venezuela. Inflação. Inteligência Artificial. FMEA.

RESUMEN

Este artículo aborda la crisis migratoria y humanitaria en Venezuela, con foco en el análisis de las raíces económicas y sociales de este fenómeno complejo. Para comprender y abordar la crisis de manera integral, se aplicaron el Análisis de Modo y Efecto de Falla (FMEA) y el Análisis de Árbol de Eventos (ETA), con resultados comparables a los de dos inteligencias artificiales (IA), Google Bard y ChatGPT. Además, el artículo empleó un modelo econométrico robusto de regresión múltiple para investigar el impacto de variables socioeconómicas en la migración neta venezolana en el período de 1998 a 2022. Los resultados revelaron que factores como la inflación, la deuda bruta, la producción petrolera y la tasa de mortalidad desempeñaron papeles significativos en la migración masiva observada. Estas conclusiones son esenciales para entender las dinámicas económicas subyacentes a la crisis y pueden contribuir al desarrollo de políticas más eficaces y sostenibles para enfrentarla.

Palabras clave: Migración. Venezuela. Inflación. Inteligencia Artificial. FMEA.

1 INTRODUCTION

Historical accounts indicate that Venezuela's oil industry took off in the 1920s, after landmark discoveries, spurring investment in infrastructure and public services (Roy & Cheatham, 2024). Venezuela holds the world's largest proven fossil fuel reserves, according to OPEC's Annual Statistical Bulletin, the country held about 303.6 billion barrels of proved crude reserves at end-2020 (OPEC, 2021). Oil exports have been the main source of income for decades, and both production and prices have had a decisive impact on the nation's economy, directly influencing national income and the government's capacity to provide basic public services, as discussed by Kleszczyńska (2020).

Venezuela's export earnings have historically been overwhelmingly oil-dependent, with oil accounting for well over 90% of merchandise exports in many periods (Roy & Cheatham, 2024). The present study indicates that the main factors leading to the crisis began in 2014, when the price of oil dropped sharply in the international market from around US\$100 to less than US\$40 by the end of 2015, as reported by the U.S. Energy Information Administration (EIA, 2016). Crespo and Zambrano (2018) explain that this price shock had a strong impact on the Venezuelan economy, reducing government revenues and compromising the budget for social programs that benefited a large share of the population. The outcome was a deep recession, reflected in the fall of GDP, hyperinflation, shortages of food and medicine, rising poverty and violence, and declining oil production. Vera (2015) analyzes macro-policy and oil governance over 1999–2014, highlighting institutional and policy vulnerabilities that predated and later amplified the downturn.

According to Tapia et al. (2022), the Venezuelan economy began to experience one of the sharpest declines ever recorded in peacetime, marking a serious humanitarian crisis. This process of deterioration has advanced rapidly, leading the country into political, economic, and social collapse, as observed by Venezuelan and Ausman (2019). In this context, millions of Venezuelans decided to leave the country in search of better living conditions. More than 7.1 million people emigrated from Venezuela between the years 2015 and 2023 (R4V, 2023).

This research project aims to conduct a detailed analysis of the systemic crisis currently affecting Venezuela and its economic impacts, which distort national institutions and lead to serious social issues such as extreme poverty, poor sanitary conditions, and a rapid increase in violence. The central hypothesis of this study is that the combined effects of these factors create a situation of extreme vulnerability for most Venezuelans. In conditions of severe poverty, individuals struggle to access food, healthcare, education, and economic opportunities, which drives them to migrate in search of better living standards.

Based on the principle of economic rationality proposed by Varian (1978), rational individuals are understood to make decisions after carefully evaluating the costs and benefits of their choices. In the context of migration, these individuals compare the opportunities available in their home country with those elsewhere. When external options offer better living conditions, migration becomes a rational decision, as pointed out by Stahl (1983). Addressing the economic principles relevant to migration decisions and based on the literature review, contextualizing the current Venezuelan scenario will serve as the starting point for building a qualitative strand. This approach is intended to justify the research direction, given that the object of study concerns the largest population exodus in Latin American history and one of the major humanitarian crises of the twenty-first century, comparable only to the poorest countries of Sub-Saharan Africa and to Middle Eastern countries in armed conflict such as Syria, Yemen, and Sudan. Mu and Hu (2018) examined the efficiency and stability of the Venezuelan economy and argued that three factors heightened uncertainty about the country: (1) an extreme dependence on the oil industry as the sole wealth-generating sector; (2) an inefficient regulatory system; and (3) slow and unresponsive reactions to external changes.

In selecting a model, the principle of parsimony will be followed, seeking the smallest number of parameters that adequately represent the time series. This principle, attributed to Burnham and Anderson (2002) is commonly interpreted as simpler models fit comparably well against overspecified models. Building a robust model to forecast Venezuela's net population flows will therefore require calibration to obtain the best estimates of known parameters. Complex phenomena demand sophisticated analysis grounded in solid evidence while also adhering to caution and moderation in the use of data and tools; this is not a trivial task. Nevertheless, given the social and humanitarian relevance of the topic, and considering that the databases come from official sources and are open source, this article aims to construct an econometric regression model in Python and compare its outputs with the results obtained by data processing using Artificial Intelligences (AI) such as Google Bard and ChatGPT-4, whose codebases operate as black boxes, both supported by GitHub Copilot.

Constructing a robust multiple regression econometric model with covariates selected from the academic literature and implemented in Python to process data for the period 1998–2022 can simultaneously satisfy two risk analysis and mitigation frameworks: Failure Mode and Effects Analysis (FMEA) and Event Tree Analysis (ETA), as discussed by the International Organization for Standardization (ISO, 2019). This approach can provide the model with sufficient computational capability to handle cutting-edge data when compared with current standards, given that AIs are an advanced tool when synchronized with a copilot, that can

access the internet, perform keyword- and topic-based searches, analyze databases, and optimize outputs while formulating responses.

This study is organized as follows, in addition to this Introduction. Section 2 presents a literature review on the determinants of migration within Venezuela's oil-dependent economy. Section 3 details the empirical methodology used for specifying the econometric model. Section 4 reports the main findings and analyzes the results. Finally, Section 5 offers the concluding remarks.

2 THEORETICAL FRAMEWORK

The reasons for migration from one country to another are diverse and may include economic motives, such as the search for better job opportunities, geographic proximity, and economic stability; social reasons, such as reuniting with family members and obtaining access to quality services; political motives, such as escaping persecution and seeking political and personal stability; in addition to the pursuit of cultural and personal experiences, as Castelli (2018) explains.

To explain the drivers of emigration for a Venezuelan citizen, the Refugee and Migrant Needs Analysis (RMNA) was developed by the Regional Inter-Agency Coordination Platform for Refugees and Migrants from Venezuela (R4V). According to R4V (2023), Venezuelan migrants sought destinations that offered safer places, opportunities to obtain income, and access to basic services. This is because the country faces a series of economic conditions that undermine the population's well-being, such as product shortages, hyperinflation, political instability, and violence, as noted by Castro (2020).

Given this scenario, R4V (2023) reports that more than 7.1 million emigrants left Venezuela between 2015 and 2023, with more than 80% hosted in 17 countries in Latin America and the Caribbean. However, the International Organization for Migration (IOM, 2020) indicates that these individuals have heterogeneous socioeconomic profiles and intentions when settling in host countries. IOM (2020) also observes that Venezuelans who move to neighboring countries (for example, Brazil and Colombia) are younger and have relatively lower levels of education and access to health care compared to Venezuelans who moved to more distant countries, where half have some level of higher education (for example, Argentina, Chile, Costa Rica, and Uruguay). Considering this, IOM (2020) concludes that there is a tendency for migrants with higher technical qualifications to move farther from their country of origin.

Nevertheless, within host countries refugees face several setbacks. As the report from R4V (2023) indicates, approximately 50% of Venezuelan migrants present in Latin America and

the Caribbean face difficulties in accessing food, education, health care and stable employment. In addition to documentation barriers, R4V (2023) points out that low wages further complicate Venezuelans capacity for subsistence. Despite these challenges, IOM (2020) notes that approximately 80% of these individuals intend to remain where they are, as they consider this to be the best decision for their own and their families well-being. To understand the scenario that generated this mass exodus from Venezuela, it is worth contextualizing the importance of oil to this economy.

2.1 RELATIONSHIP BETWEEN THE VENEZUELAN ECONOMY AND WEALTH VIA OIL

The importance of oil to the world is undeniable, as it is a fundamental energy source for many countries. According to OPEC's Annual Statistical Bulletin (2021), Venezuela holds the world's largest proved crude oil reserves, and export profiles show that oil has historically dominated the country's merchandise exports. Kleszczyńska (2020) notes that production and the international price of this asset directly affect national income and local economic performance. However, excessive dependence on oil can have negative consequences.

The Dutch disease is an economic phenomenon that arises when a country experiences a boom in a natural resource sector, which leads to an artificial appreciation of the domestic currency, taking a heavy dependence on the extractive sector due to strong international demand. Corden and Neary (1982) coined the term in response to the decline of manufacturing and the rise in unemployment in the Netherlands in the 1970s after the discovery of oil and gas in the North Sea. This phenomenon comprises two main effects: the spending effect and the resource-movement effect, as described by Fardmanesh (1991). The first occurs when rising natural resource prices initially trigger a real appreciation that increases the profitability of the appreciated export; this price increase can drive currency appreciation and harm the competitiveness of tradable sectors unrelated to natural resources. According to Corden and Neary (1982), the resource-movement effect draws labor and capital toward the booming resource and non-tradable sectors, squeezing other tradable activities.

In the Venezuelan context, an economy highly dependent on income from fossil fuel exports. Fardmanesh (1991) observes that a sharp rise in oil prices harms tradable sectors such as manufacturing and agriculture, depressing their output in favor of the expanding oil market. Kulkarni and Nicholson (2010) further report a high and significant correlation between Venezuela's dollar reserves, money supply, and inflation. Costa and Olivo (2008) find that money growth and government spending in oil-exporting countries are highly correlated with the commodity's price; thus, the terms-of-trade gain is tied especially to price and less to

exported volume. For petrostates operating under government-managed fixed exchange rates, interventions to hold the peg during positive oil-price shocks can be expansionary in monetary terms, as discussed by Mercedes da Costa (2008). As a result, the domestic market becomes more exposed to price fluctuations, culminating in high inflation.

As these effects unfold, exports from non-oil sectors decline. In the domestic market, consumers can import cheaper goods that other countries produce with comparative advantage, further deepening the decline of sectors unrelated to the appreciated commodity. Wang (2022) summarizes that there is a general deterioration in the terms of trade: production becomes lower than it originally was in markets unrelated to the natural resource, while it becomes relatively higher for the good linked to the disease. In Venezuela, Vidal and Mazzali (2019) note that more than 70% of food is imported and that domestic pharmaceutical production is practically nonexistent. Consequently, sectors essential for population well-being become dependent on foreign policy.

Over the last decade, this dependence was further strained by successive sanctions imposed on the Venezuelan government. The U.S. Department of the Treasury (2023) reports that, after the United States deemed Venezuela a national security threat in 2015, sanctions were applied to Venezuelan officials and, in 2017, new debt, shares, and bonds issued by the Venezuelan government and its state-owned companies were barred from U.S. financial markets. In 2019, an economic embargo froze all Venezuelan government property and assets in the United States, including those of the Central Bank of Venezuela. Gratius (2021) explains that these measures aimed to block Venezuela's international trade and curb its ability to raise funds abroad.

The most evident effects of the sanctions were declines in trade, foreign investment, and development assistance. The European Commission (2019) indicates that limited trade relations between Venezuela and the European Union drove exports down from €6.5 billion in 2012 to €0.69 billion in 2019, while imports were reduced by approximately 50% over the same period. In the United States, the U.S. Census Bureau (2019) reports that Venezuelan exports fell from \$38.7 billion to \$1.9 billion in 2019.

When external markets are restricted and the state has fewer resources, importing food, medicines, and other essential supplies becomes even more difficult. Moreover, constraints on the oil industry's trade affect the core of an economy already suffering from Dutch disease. As the international price of commodities drops significantly, the economic and humanitarian crisis deepens gradually. Human Rights Watch (2019) observes that, despite the country's wealth in

a resource with strong global demand, the population faces high inflation and shortages of basic goods, conditions that can motivate migration.

3 METHODOLOGY

3.1 FAILURE MODE AND EFFECTS ANALYSIS AND EVENT TREE ANALYSIS

Failure Mode and Effects Analysis is a systematic technique used across fields such as engineering, manufacturing, and economics to identify and mitigate potential risks. As described by Cristea and Constantinescu (2017), FMEA rates severity, occurrence, and detectability on 1–10 ordinal scales before computing the Risk Priority Number (RPN). The RPN is calculated for each failure mode to rank and prioritize the identified failure modes. The formula for calculating the RPN is presented by McDermott et al. (2009):

$$RPN = Severity (S) \times Occurrence (O) \times Detectability (D) \quad (1)$$

Severity (S) represents the magnitude of the impact or consequence if the failure mode occurs. Thus, 1 is the lowest rating, and 10 indicates very high severity, when a potential failure mode affects the safe operation of the system without warning. Occurrence (O) indicates the likelihood that the failure mode will occur; 1 reflects virtually no chance of occurrence and 10 reflects a very high probability with failure being nearly inevitable. Detectability (D) refers to the ability to identify the failure mode before it causes significant impacts; 1 indicates the greatest detection potential, and 10 represents complete uncertainty.

The result of the RPN calculation ranges from 1 to 1000. Higher-RPN failure modes indicate greater risk and require more attention and action to reduce their probability of occurrence or minimize their consequences, as emphasized by McDermott et al. (2009). Addressing social and economic crises requires identifying critical factors that contribute to instability, such as inflation rates, unemployment rates, and fiscal policies. In addition, analyzing the probability of political unrest, corruption, and social tensions can help clarify what exacerbates the crisis. In the context of the Venezuelan migration crisis, FMEA can be applied to identify failure modes associated with its main causes, such as economic crisis, political instability, and lack of access to essential resources. By decomposing the problem into individual failure modes and evaluating their impact, decision-makers can gain a deeper understanding of the underlying causes and vulnerabilities that contribute to the crisis.

On the other hand, complementing FMEA with another risk analysis technique, such as Event Tree Analysis, can offer a more comprehensive understanding of the crisis. ETA allows

modeling complex scenarios and calculating probabilities for spontaneous events, as discussed explained by Fernandes, Cristina, and Filho (2022). Its tree-like structure facilitates the visualization and understanding of possible paths that lead to an outcome. For example: let A be an external event (final event) for which we want to analyze possible causes and consequences, the probability of event A occurring, $P(A)$, can be seen using the ETA formula:

$$P(A) = \sum_i P(B_i) P(A | B_i), \quad (2)$$

Where:

$\{B_i\}$ denotes a mutually exclusive and exhaustive set of initiating scenarios; accordingly, $P(B_i)$ is the probability of scenario B_i , and $P(A | B_i)$ is the conditional probability of the outcome given that scenario (Ross, 2019).

In event tree analysis, according to ISO (2019), the probability of a given outcome is obtained by multiplying branch probabilities along each path to that outcome and then summing across relevant paths.

In sum, combining FMEA and ETA offers complementary perspectives on failure modes and consequence pathways, as outlined in ISO (2019) and illustrated in applied risk studies such as Fernandes et al. (2022). Conducting a multiple regression analysis technique capable of simultaneously satisfying an FMEA and an ETA constitutes a sophisticated tool used to control the effect of confounding variables in economic models. These variables can influence outcomes and lead to spurious relationships between independent and dependent variables, causing biased or incorrect results, as highlighted by Cristea and Constantinescu (2017). According to Wooldridge (2013) and Hernán and Robins (2020), multiple regression and doubly robust estimators address confounding in observational data as a separate statistical layer that can complement, but does not substitute, qualitative or semiquantitative risk analyses. Thus, both exposure models and outcome models can be adjusted, leading to more accurate estimates of the effects of the variables of interest.

3.2 ECONOMETRIC MODEL SPECIFICATION

When considering the complex nature of economic data and following the principle of parsimony, we employ a robust regression approach to mitigate potential deviations from classical assumptions. As described by Huber (1981), we estimate a robust M-estimator via IRLS with the Huber loss, and we compute heteroskedasticity-consistent standard errors using

the HC1 (Huber–White) sandwich covariance based on White (1980). The robust regression expressed below enables efficient analysis of the impact of macroeconomic factors on Venezuelan net migration. The adopted specification is:

net_migration

$$\begin{aligned}
 &= \beta_0 + \beta_1 \times \text{inflation} + \beta_2 \times \text{gross_debt} + \beta_3 \times \text{mortality} \\
 &+ \beta_4 \times \text{oil_production} + \beta_5 \times \text{youth_employment} + \beta_6 \times \text{hunger} \\
 &+ \beta_7 \times \text{primary_enrollment} + \beta_8 \times \text{oil_price} + \varepsilon,
 \end{aligned} \tag{3}$$

Where:

β_0 is the intercept, β_i with $i = 1, \dots, 8$ represents the coefficients of the explanatory variables, and ε is the random error term. Table 1 presents the regression variables, data sources, quantitative scale, and the transformation method used to achieve stationarity.

Table 1

Presentation of the variables studied for Venezuela

Variable	Description	Transformation Method for Stationarity	Source and Code Series
Net_migration	Dependent variable of the model: number of immigrants (people entering a given country) minus the number of emigrants (people leaving the country).	Differencing, order 3; KNN imputation	(World Bank, 2023, WDI SM.PO.P.NET.M)
inflation	Inflation rate, consumer prices at end of period (annual percentage change).	Differencing, order 8; KNN imputation; Differencing, order 1; KNN imputation	(IMF, 2023, WEO—CPI)
gross_debt	Gross public sector debt (% of GDP).	Differencing, order 2; KNN imputation; Smoothing	(IMF, 2023, WEO—GGXWDG_NGDP)
mortality	Mortality rate (deaths per 1,000 people).	Differencing, order 4; KNN imputation; Smoothing; Logarithm	(World Bank, 2023, WDI SP.DY.N.CDR.T.IN)
oil_production	Total oil production (million barrels per day, annual average).	Differencing, order 1; KNN imputation	(EIA, 2023—crude oil)

			product ion)
youth_ employ ment	Labor force participation rate (% of population aged 15 to 24).	None	(World Bank, 2023, WDI SL.TLF .1524.Z S)
hunger	Hunger statistics (% of the population).	None	(FAO, 2023, FAOST AT— POU)
primary_ enroll ment	School enrollment rate at the primary level (%).	Differencing, order 1; KNN imputation	(World Bank, 2023, WDI SE.PR M.NEN R)
oil_pric e	End-of-period oil price (US\$).	Logarithm; Differencing, order 1; KNN imputation	(EIA, 2023— Europe Brent spot price)

Stationarity is fundamental for time-series regression, to achieve this, three methods are employed. First, differencing consists of subtracting previous values of the series, resulting in a series of differences; the order of differencing determines how many past steps are subtracted. Second, smoothing uses techniques such as moving averages to reduce random variation and highlight long-term patterns. Third, the natural logarithm (ln) is applied to stabilize variance in series with exponential growth, making them more suitable for analysis. As described by Batista and Monard (2003), the KNN imputation method fills gaps due to missing data using values observed nearby in time, which compensates for the loss of observations during differencing. As noted by Box et al. (2016) these transformations make the series more suitable for econometric modeling and forecasting.

4 RESULTS

This section presents the results of the robust regression model used to investigate the determinants of net migration in an economic context. The model was fitted with data collected over the period 1998 to 2022, with the aim of understanding how macroeconomic variables influence population migration from Venezuela.

Table 2 displays the results of eight specifications of economic models obtained through an iterative procedure. Initially, all variables under study were included in model (1). In each

subsequent iteration, the variable with the lowest level of significance (p-value) was removed, until only one significant variable remained in the final model (8). This selection process sought to identify the most parsimonious and statistically relevant configuration for the economic analysis in question. Among the specifications presented, model (5) and model (7) deserve emphasis. In model (5), four variables proved statistically significant, contributing to the explanation of 61.75% of the variation in net migration. In model (7), two variables were statistically significant and explained 43.97% of the observed variation in net migration.

Table 2

Results of robust regression models, 1998 to 2022 (n = 25)

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R ²	0,6627	0,6579	0,6413	0,6427	0,6175	0,5279	0,4397	0,3026
constant	-247.500 (575.000)	-287.000 (531.000)	-396.400 (478.000)	-517.400 (418.000)	154.900* (85.100)	115.700 (48.400)	7998 (13.500)	-118 (739)
inflation	0,0608** * (0,014)	0,0592*** (0,013)	0,0615*** (0,012)	0,0604*** (0,012)	0,0674*** (0,010)	0,0649*** (0,006)	0,0626*** (0,003)	0,0524*** (0,000)
gross_debt	- 12.530** * (3.590)	- 13.320*** (3.086)	- 12.910*** (2.929)	- 12.370*** (2.830)	- 11.380*** (2.617)	-8.949*** (1.421)	- 6612*** (891)	
mortality	- 4.036.00 0* (2.080.00)	- 3.980.000 ** (1.920.000)	- 4.046.000 ** (1.820.000)	- 3.788.000 ** (1.760.000)	- 3.907.000 ** (1.620.000)	- 2.454.000 *** (928.000)		
oil_production	- 602.300* * (279.000)	- 557.400** (239.000)	- 481.900** (225.000)	- 440.100** (209.000)	- 348.900** (175.000)			
youth_employment	10.750 (12.200)	11.670 (11.200)	14.060 (10.100)	15.490 (9.419)				
hunger	-7.638 (8.309)	-6.826 (7.522)	-4.969 (6.653)					
primary_enrollment	26.790 (36.200)	26.530 (33.700)						
oil_price	63.500 (135.000)							

Note: Standard error in parentheses; *** p-value < 0.01, ** p-value < 0.05, * p-value < 0.1.

Model (5) provides coefficient estimates indicating the effect of the independent variables on net migration while holding the others constant. The constant suggests that, when all independent variables are zero, net migration is approximately 154.900 units. Inflation has a significant positive effect, being associated with an increase of 0.0674 units in net migration for

each one-unit increase in inflation. By contrast, gross debt, the mortality rate, and oil production have significant negative effects, being associated with decreases of 11.380 units, 3.907.000 units, and 348.900 units in net migration, respectively, for each one-unit increase in those variables. These findings are valuable for understanding how these economic variables influence population movements and migration.

Similarly, in model (7), the positive coefficient for the variable “inflation” indicates that a one-unit increase in inflation is associated with a rise of 0.0626 units in net migration. Conversely, the negative coefficient for the variable “gross debt” suggests that a one-unit increase in gross debt is associated with a decrease of 6.612 units in net migration. The constant is not statistically significant ($p = 0.555$), indicating that its value does not exert a statistically relevant effect on net migration when all other independent variables are zero. Together these results are fundamental to understanding the economic mechanisms underlying population movements and migration, highlighting the importance of inflation and gross debt as influential factors in this context.

4.1 FMEA AND ETA RESULTS

This section presents a structured approach based on the Failure Mode and Effects Analysis technique, widely used across various engineering fields, to identify, categorize, and prioritize the possible contributing factors that led to the emergence of this migration crisis. Through this detailed investigation, the objective is to provide a comprehensive and well-grounded analytical framework that can contribute meaningfully to understanding the origins and implications of the Venezuelan migration crisis and, consequently, support the development of effective and sustainable strategies to address it. Table 3 presents a comprehensive analysis of failure modes and their relevance in the context of the Venezuelan migration crisis. The assessment of the Risk Priority Number indicates that, for the Bard system, the main failure modes are associated with a sharp decline in oil production and economic instability, whereas for the ChatGPT system, the principal failure modes relate to mortality and collapse of the health system, along with runaway inflation. Figures 1 and 2 provide a graphical analysis of the RPN and allow an examination of the relative importance of each failure mode.

Table 3

FMEA for the Migration Crisis in Venezuela, BARD vs. ChatGPT

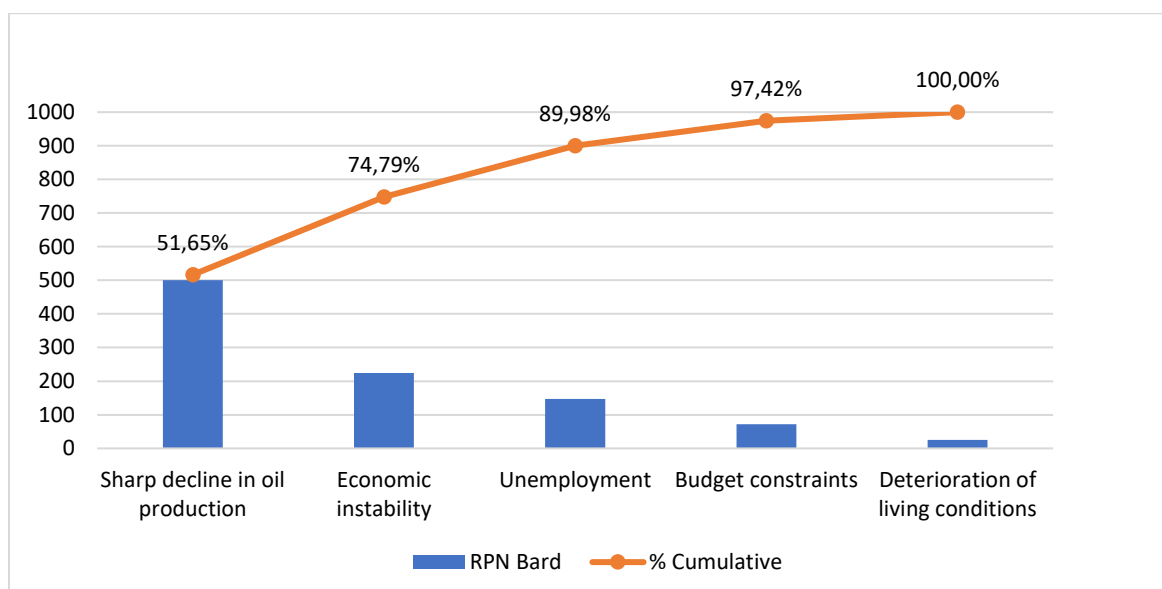
Failure Mode	Severity	Occurrence	Detectability	RPN
BARD				
Sharp decline in oil production	10	10	5	500

Economic instability	8	8	4	224
Unemployment	7	7	3	147
Budget constraints	6	6	2	72
Deterioration of living conditions	5	5	1	25
ChatGPT				
Mortality and collapse of the health system	9	7	9	567
Runaway inflation	9	8	7	504
Rising gross debt	8	7	8	448
High unemployment	8	9	6	432
Drop in oil production	7	6	8	336

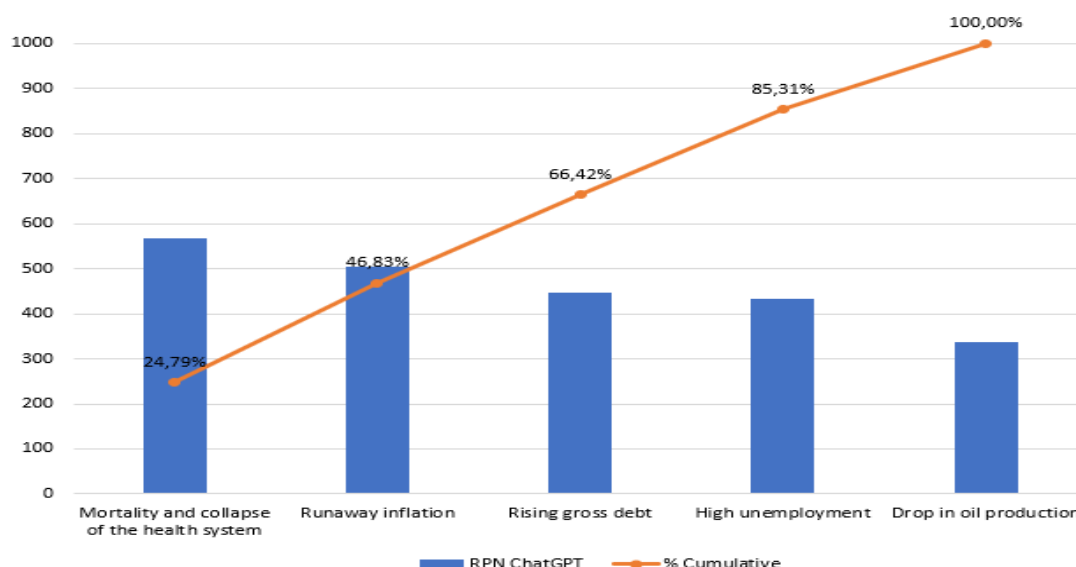
Source: Google (2023) and OpenAI (2023).

Figure 1

RPN (Risk Priority Number) analysis, Google Bard



According to Figure 1, the analysis conducted with Google Bard identifies that the two main failure modes in Venezuela's migration crisis are the sharp decline in oil production and economic instability, which together account for approximately 74.79% of risk prioritization. This concentration suggests a relationship close to the Pareto optimum or the 80–20 rule, which proposes that, in many situations, approximately 80% of effects are caused by 20% of causes. In this context, it indicates that most of the crisis's impact is driven by a relatively small set of critical factors, underscoring the importance of these priority failure modes in triggering and shaping the evolution of the Venezuelan migration problem.

Figure 2*RPN (Risk Priority Number) analysis, ChatGPT*

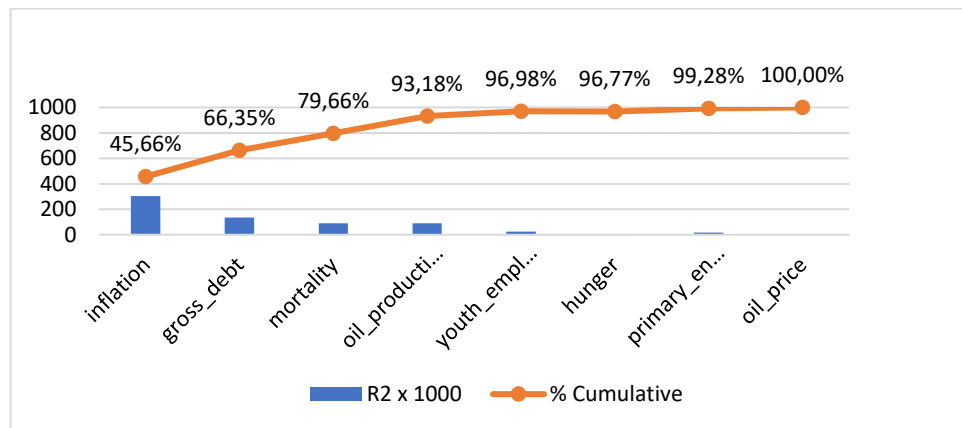
Based on Figure 2, it can be observed that the ChatGPT analysis identified four principal failure modes during the Venezuelan migration crisis: mortality and collapse of the health system, runaway inflation, rising gross debt, and high unemployment. By totaling 85.31% of the risk prioritization associated with the crisis, these factors approach the Pareto optimum indicated by the system.

As a complement, Figure 3 presents a detailed analysis of failure modes using the robust regression models developed in the previous section. Prioritization was based on the R^2 criterion, widely used in regression analysis to measure the model's fit to the observed data. The relative relevance of each variable was calculated through the change in the model's coefficient of determination R^2 after its removal during the iterative process. This approach makes it possible to understand each factor's contribution to the model and facilitates the identification of critical aspects in risk analysis.

Through Figure 3, it is observed that inflation, gross debt, and mortality jointly account for 79.66% of the explanatory power of the robust econometric regression models, approaching the Pareto optimum. This observation indicates that these three factors play an important role in understanding the Venezuelan migration crisis, making them priorities due to their significant association with the phenomenon under analysis.

Figure 3

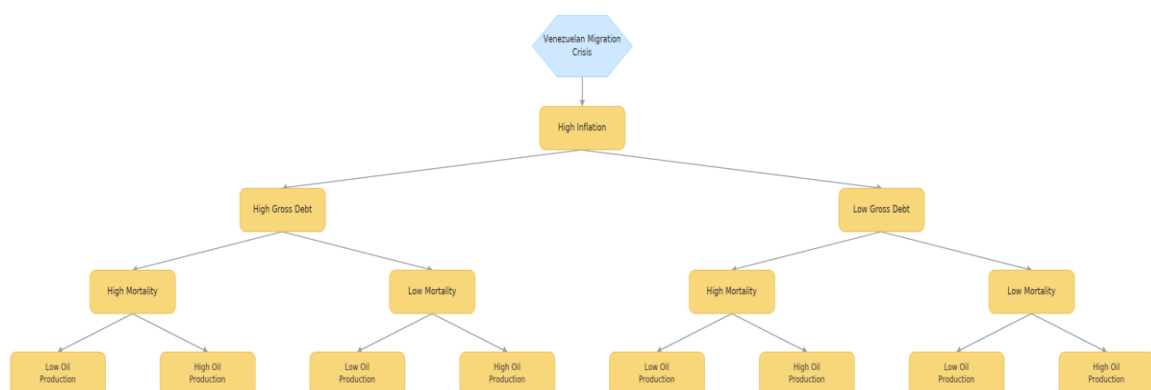
Failure Mode Analysis based on the coefficient of determination R^2



Through ETA, it was possible to investigate the multiple branches of the critical events that led to the migration crisis, analyzing the underlying causes and their interconnections. The ETA in Figure 4 indicates that the Venezuelan migration crisis was driven by a series of interconnected events. The final event of interest is mass population migration, and the underlying causes include high inflation rates, rising gross debt, elevated mortality, and declining oil production. These socioeconomic factors created an environment of instability, high unemployment, and widespread socioeconomic hardship, leading many Venezuelans to seek better opportunities in other countries.

Figure 4

Event Tree Analysis in Venezuela Case



5 CONCLUSION

In general, conducting social and economic experiments on topics involving public policy can become subject to ideological debate and personal opinions. This article chose to conduct

an analysis based on observable variables to identify patterns, trends, or changes over the period from 1998 to 2022. Building a literature-grounded model to characterize the Venezuelan migration crisis as an undesirable event, using econometric regressions with an AI synchronized to a copilot trained to perform statistical significance analysis in the context of humanitarian causes, can be useful for better understanding the factors that affect these causes and for identifying more effective strategies to address them. The AI can be trained to collect, organize, and analyze large volumes of data related to humanitarian causes—such as demographic information, socioeconomic indicators, and health data—and to identify correlations among variables and the factors most relevant to the success or failure of a specific humanitarian cause.

The academic relevance lies in experimenting with an AI synchronized to a copilot with high computational power that, through data processing, can be trained to perform statistical significance analysis to characterize the Venezuelan migration crisis as an undesirable event, identifying the main variables that generate its failure modes, provided that all necessary datasets and correct commands are supplied.

Finally, the analysis can be valuable for three reasons. First, it avoids polarization by relying on observable variables, ensuring impartiality by focusing on data and evidence rather than ideological opinions. Second, with the use of artificial intelligence and a qualified copilot, it is possible to develop complex and objective models, enabling broader analysis and the identification of important correlations among variables. Third, the proposed analysis does not deviate from the core of the crisis with social and humanitarian issues such as quality of life and conditions for development as relevant factors that drive migration, so this data-driven and objective approach provides a clearer view of the problems at hand, contributing to informed, evidence-based decision-making aimed at mitigating the crisis's negative impact and seeking sustainable solutions and adequate assistance for the most vulnerable populations.

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URBAN PARKS AS INSTRUMENTS FOR SOCIO-ENVIRONMENTAL PLANNING AND PUBLIC POLICY: A SYSTEMATIC REVIEW

PARQUES URBANOS COMO INSTRUMENTOS PARA O PLANEJAMENTO SOCIOAMBIENTAL E POLÍTICAS PÚBLICAS: UMA REVISÃO SISTEMÁTICA

PARQUES URBANOS COMO INSTRUMENTOS PARA LA PLANIFICACIÓN SOCIOAMBIENTAL Y LAS POLÍTICAS PÚBLICAS: UNA REVISIÓN SISTEMÁTICA



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ABSTRACT

This study sought to analyze urban parks by assessing their contributions to sustainability, social justice, and community well-being. The research was conducted through a systematic review structured according to the PRISMA 2020 protocol, including bibliometric and bibliographic analyses of international databases (Scopus and Web of Science) covering the period from 2020 to 2025. The tools used included Rayyan for screening and duplicate exclusion; VOSviewer and Bibliometrix for bibliometric analysis; and Zotero, Mendeley, and Excel for reference management and organization. Five questions guided the study in order to achieve its objective: (i) which dimensions are addressed by recent research on sustainable urban parks? (ii) what are the main themes discussed within these dimensions? (iii) which methodologies and analytical tools have been applied? (iv) which conceptual and methodological gaps remain in the literature? and (v) which future research directions can be suggested? A total of 61 highly relevant articles were selected, confirming that parks function as instruments of social inclusion, health promotion, and mitigation of environmental impacts, while also fostering sustainability. In response to the proposed questions, the review showed that recent studies on urban parks have increased, particularly those addressing health, sociospatial justice, quality, management, and socioeconomic impacts, and discussing themes such as mental health, accessibility, green gentrification, and civic participation. Although diverse methodologies have been applied, gaps persist, including the limited number of longitudinal studies, differences between developed and developing countries, lack of maintenance and safety, and the absence of studies on the effects of parks as therapeutic spaces for neurodivergent populations. It is concluded that urban parks should

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be recognized as critical infrastructures for public health, social inclusion, and climate resilience.

Keywords: Urban Parks. Green Infrastructure. Sustainability. Environmental Justice. Smart City. Urban Planning.

RESUMO

Este estudo buscou analisar os parques urbanos, avaliando suas contribuições para a sustentabilidade, a justiça social e o bem-estar comunitário. A pesquisa foi conduzida por meio de uma revisão sistemática estruturada de acordo com o protocolo PRISMA 2020, incluindo análises bibliométricas e bibliográficas de bases de dados internacionais (Scopus e Web of Science), abrangendo o período de 2020 a 2025. As ferramentas utilizadas incluíram Rayyan para triagem e exclusão de duplicatas; VOSviewer e Bibliometrix para análise bibliométrica; e Zotero, Mendeley e Excel para gerenciamento e organização das referências. Cinco questões orientaram o estudo para alcançar seu objetivo: (i) quais dimensões são abordadas pelas pesquisas recentes sobre parques urbanos sustentáveis? (ii) quais são os principais temas discutidos dentro dessas dimensões? (iii) quais metodologias e ferramentas analíticas têm sido aplicadas? (iv) quais lacunas conceituais e metodológicas permanecem na literatura? e (v) quais direções futuras de pesquisa podem ser sugeridas? Um total de 61 artigos altamente relevantes foi selecionado, confirmando que os parques funcionam como instrumentos de inclusão social, promoção da saúde e mitigação de impactos ambientais, ao mesmo tempo em que fomentam a sustentabilidade. Em resposta às questões propostas, a revisão demonstrou que os estudos recentes sobre parques urbanos têm aumentado, especialmente aqueles que abordam saúde, justiça socioespacial, qualidade, gestão e impactos socioeconômicos, discutindo temas como saúde mental, acessibilidade, gentrificação verde e participação cívica. Embora diversas metodologias tenham sido aplicadas, persistem lacunas, incluindo o número limitado de estudos longitudinais, diferenças entre países desenvolvidos e em desenvolvimento, falta de manutenção e segurança, e a ausência de estudos sobre os efeitos dos parques como espaços terapêuticos para populações neurodivergentes. Conclui-se que os parques urbanos devem ser reconhecidos como infraestruturas críticas para a saúde pública, inclusão social e resiliência climática.

Palavras-chave: Parques Urbanos. Infraestrutura Verde. Sustentabilidade. Justiça Ambiental. Cidade Inteligente. Planejamento Urbano.

RESUMEN

Este estudio tuvo como objetivo analizar los parques urbanos, evaluando sus contribuciones a la sostenibilidad, la justicia social y el bienestar comunitario. La investigación se llevó a cabo mediante una revisión sistemática estructurada de acuerdo con el protocolo PRISMA 2020, incluyendo análisis bibliométricos y bibliográficos de bases de datos internacionales (Scopus y Web of Science), cubriendo el período de 2020 a 2025. Las herramientas utilizadas incluyeron Rayyan para el cribado y la eliminación de duplicados; VOSviewer y Bibliometrix para el análisis bibliométrico; y Zotero, Mendeley y Excel para la gestión y organización de referencias. Cinco preguntas guiaron el estudio para alcanzar su objetivo: (i) ¿qué dimensiones son abordadas por las investigaciones recientes sobre parques urbanos sostenibles? (ii) ¿cuáles son los principales temas discutidos dentro de estas dimensiones? (iii) ¿qué metodologías y herramientas analíticas se han aplicado? (iv) ¿qué vacíos conceptuales y metodológicos permanecen en la literatura? y (v) ¿qué direcciones futuras de investigación pueden sugerirse? Se seleccionaron un total de 61 artículos

altamente relevantes, confirmando que los parques funcionan como instrumentos de inclusión social, promoción de la salud y mitigación de impactos ambientales, al mismo tiempo que fomentan la sostenibilidad. En respuesta a las preguntas planteadas, la revisión mostró que los estudios recientes sobre parques urbanos han aumentado, especialmente aquellos que abordan la salud, la justicia socioespacial, la calidad, la gestión y los impactos socioeconómicos, discutiendo temas como la salud mental, la accesibilidad, la gentrificación verde y la participación cívica. Aunque se han aplicado diversas metodologías, persisten vacíos, incluyendo el número limitado de estudios longitudinales, las diferencias entre países desarrollados y en desarrollo, la falta de mantenimiento y seguridad, y la ausencia de estudios sobre los efectos de los parques como espacios terapéuticos para poblaciones neurodivergentes. Se concluye que los parques urbanos deben ser reconocidos como infraestructuras críticas para la salud pública, la inclusión social y la resiliencia climática.

Palabras clave: Parques Urbanos. Infraestructura Verde. Sostenibilidad. Justicia Ambiental. Ciudad Inteligente. Planificación Urbana.

1 INTRODUCTION

Accelerated urbanization since the late twentieth century has increased pressure on urban systems and, as a result, has led to the emergence of sociospatial inequalities, climate change, and public health challenges [1][2][3][4]. Simultaneously, the need for resilient infrastructure has led policymakers to rethink urban structures and open spaces, and to recognize urban parks as strategic solutions [5][6][7][8].

Urban parks function as multifunctional green infrastructure, providing environmental benefits such as thermal regulation, flood mitigation, and improved air quality [9][10][11][12][13]. In addition, they offer social and health benefits, including encouragement of physical activity, stress reduction, and strengthening of community cohesion [14][15][16][17][18][19]. The global literature on this topic indicates that the presence of green areas is associated with improvements in urban quality of life [20][21][22][23]. Despite this, the unequal distribution of these benefits reflects barriers to access, sociospatial segregation, and processes of green gentrification [24][25][26][27][28][29][30] as well as shortcomings in urban planning [31]. Structural factors such as income level, ethnicity, housing, and living conditions directly influence health and intensify inequalities in areas undergoing gentrification [32]. Similar results were identified in Beijing, where older adults and low-income residents showed greater dependence on park quality for health maintenance [33][34]. In New York City, the unequal distribution of green spaces reflected different socioeconomic profiles across neighborhoods, resulting in varied impacts on different social groups [21]. Similarly, in Hong Kong, areas with a higher concentration of ethnic minorities have parks with fewer resources and lower quality, highlighting disparities in the distribution of socioenvironmental services [35]. The creation of new parks may, paradoxically, generate processes of environmental gentrification, in which rising property values and commercial transformations ultimately displace vulnerable residents, calling for “just green enough” policies that reconcile equitable access with community permanence [36]. This concept proposes the creation of green areas that improve quality of life without triggering intense real estate valorization processes that result in the displacement of low-income residents, thereby promoting a more just and inclusive greening. Overall, these studies demonstrate the urgency of implementing urban public policies that consider justice.

In light of this, the objective of this research is to analyze and critique the international literature on urban parks as socioenvironmental infrastructure, using the PRISMA 2020 protocol [37] and bibliometric tools to ensure methodological rigor. The study seeks to answer the following five guiding questions:

- (i) which dimensions are addressed by recent research on sustainable urban parks?

- (ii) what are the main themes discussed within these dimensions?
- (iii) which methodologies and analytical tools have been applied?
- (iv) which conceptual and methodological gaps remain in the literature?
- (v) which future research directions can be suggested?

2 METHODOLOGY

This research adopted a methodology based on the PRISMA 2020 protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which is widely recognized for its transparency and scientific rigor. Since its first publication [37], PRISMA has been extensively used across different fields of knowledge, providing standardization and clarity in the stages of study identification, screening, eligibility, and inclusion. The method was structured in two complementary stages—bibliometric review and bibliographic review—supported by specialized software for data organization, analysis, and synthesis. The following subsections describe the methodological framework, the databases consulted, the PICO strategy used to formulate the search, the inclusion and exclusion criteria, the article selection process, and the instruments applied.

2.1 METHODOLOGICAL STRUCTURE OF THE SYSTEMATIC REVIEW

In the present study, searches were conducted in the Scopus and Web of Science databases using combinations of keywords formulated in accordance with the research objectives. For article screening, the Rayyan software was used [38], supporting the removal of duplicates and the selection of the most relevant studies. This tool optimizes the review process by offering filtering and classification features, ensuring greater efficiency and accuracy during the selection stage. Subsequently, VOSviewer [39], was employed for bibliometric analysis and visualization of co-authorship networks and keyword co-occurrence, and is widely used to identify trends and thematic interconnections. In addition, Bibliometrix [40] was used for advanced statistical analyses and for generating maps and scientific performance indicators, integrating the quantitative and qualitative dimensions of the review.

The systematic review was structured in two complementary stages:

- A) Bibliographic review: In the initial stage, the keywords were organized into four major thematic groups, each composed of four sub-descriptors, totaling 16 search combinations. Different configurations using Boolean operators (AND/OR) were tested to adjust query precision and reduce thematic noise. After a preliminary analysis, the descriptors were refined by eliminating redundant terms and adjusting expressions that

generated results outside the scope of the study. Subsequently, systematic filters were applied (2020–2025; articles and reviews; English language), in accordance with PRISMA guidelines [37]. To ensure conceptual precision, the PICO strategy was adopted in the final formulation, resulting in the following search string: (“urban parks” OR “urban park”) AND (“green infrastructure” OR “sustainability” OR “smart city” OR “urban planning”).

The search in the Scopus and Web of Science databases returned 2,044 records. The results were imported into the Rayyan software for duplicate identification and screening by title and abstract, resulting in 123 eligible articles. The data (123 articles) were organized and analyzed using VOSviewer, enabling the generation of graphs and clusters that highlight co-authorship networks, recurring themes, and research patterns. After full-text reading and application of the exclusion criteria, 61 studies comprised the final sample.

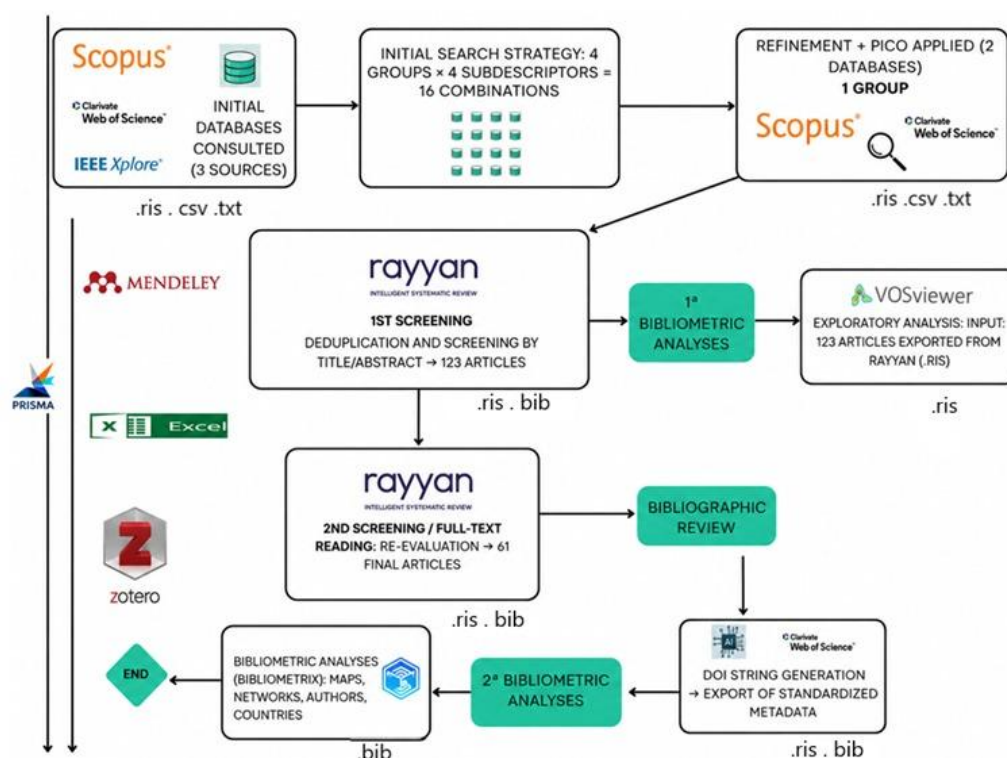
B) Bibliometric review: After defining the final set of 61 articles, the quantitative stage was initiated. Prior to the final filtering, an exploratory analysis was conducted in VOSviewer using the 123 articles previously selected in Rayyan and exported in RIS format. This preliminary step made it possible to broadly observe initial patterns, highlighting term co-occurrence networks, thematic clusters, and co-authorship relationships, thereby helping to situate the research field and to confirm the thematic consistency of the screened sample. Subsequently, the metadata of the 61 final articles were standardized. As the databases use different structures, an artificial intelligence tool was employed to generate a string containing all DOIs of the selected studies, enabling their use in the Web of Science to export complete and standardized metadata. With the standardized files, the data were processed in Bibliometrix (R), allowing advanced bibliometric analyses such as thematic maps, temporal evolution of terms, co-authorship networks, and collaboration between countries, as well as the identification of the most influential authors and journals. Mendeley was used to organize the reference database, while Excel supported the systematization and control of the studies throughout the process. This methodological workflow—exploratory analysis in VOSviewer with the initial sample of 123 articles, data standardization of the 61 final studies in the Web of Science, and advanced analysis in Bibliometrix—ensured analytical rigor, traceability, and robustness of the bibliometric results.

Thus, the chosen methodological approach ensured precision and clarity across all stages of the review, beginning with the development of the search strategy and extending

through the critical evaluation of the results obtained. The combination of bibliometric and qualitative methods enabled a comprehensive mapping of recent academic production related to urban parks, as well as the identification of global trends and conceptual gaps, thereby ensuring the reproducibility of the research. The following sections specify the databases consulted, the selection criteria, the screening process, and the tools employed, in accordance with the principles established by the PRISMA 2020 protocol [37].

Figure 1

Systematic Review Approach



2.2 DATABASES AND PICO STRATEGY

The search process followed an iterative refinement trajectory. Initially, four major keyword groups were structured: Urban Innovation and Governance, Environmental Justice and Inclusion, Circularity and Sustainability, and Urban Parks and Green Infrastructure, each subdivided into up to four subgroups of descriptors combined using the AND or OR connectors. This broad strategy aimed to capture the largest possible number of studies, even with a high level of noise. However, the preliminary analysis revealed thematic redundancies and the presence of articles outside the scope, which led to the reduction and synthesis of the groups. After successive tests, syntactic adjustments, and the application of filters (2020–2025; articles and reviews in English), a loss of relevant studies was observed, which motivated the adoption

of the PICO strategy as the basis for redefining the descriptors. Finally, a single search group was consolidated with the terms: (“urban parks” OR “urban park”) AND (“green infrastructure” OR “sustainability” OR “smart city” OR “urban planning”), applied to the Scopus and Web of Science databases, resulting in 2,044 records exported to the subsequent stages of screening and bibliometric analysis.

In compliance with PRISMA protocol criterion no. 6 (Information sources), the information sources considered in this study were therefore the Scopus and Web of Science databases, covering the period from 2020 to 2025, with the last search conducted on August 26, 2025.

According to PRISMA protocol criterion no. 5 (Eligibility criteria), it was necessary to define the inclusion and exclusion criteria for the studies in advance. To structure this process, the PICO tool (Problem, Intervention, Comparison, and Outcomes) was adopted, as it supports the formulation of research questions and the organization of search strategies.

Table 1 presents the PICO strategy developed for this study, indicating how each element (P, I, C, O) was translated into keywords and eligibility criteria, serving as the basis for defining the search terms and for selecting the articles included in the review.

Table 1

PICO Research Strategy.

PICO	Questions	Responses
P (Problem)	Which urban populations are affected by the availability and quality of urban parks and green spaces?	Communities in urban areas, with emphasis on vulnerable groups (low-income residents, minorities, children, elderly, and people with disabilities).
I (Intervention)	How can urban parks and green spaces act as green infrastructure promoting sustainability, justice, and equity?	Implementation of parks as nature-based solutions (NbS), inclusive design, sustainable urban planning, and community-oriented management.
C (Comparison)	How do cities without adequate urban parks compare in terms of health, equity, and well-being to those with well-planned parks?	Differences in health outcomes, social equity, and overall well-being between cities with well-structured urban parks and those lacking adequate green infrastructure.
O (Outcomes)	What are the impacts of urban parks on justice, equity, and community well-being?	Improved health, greater social cohesion, reduction of inequalities, promotion of environmental justice, and enhancement of urban

Based on the PICO strategy, keyword analyses were developed to guide the searches in the databases. The combinations of terms were structured gradually, undergoing several adjustments until a refined format was achieved that was capable of retrieving studies aligned with the central research problem. This process ensured that the search was sufficiently broad to map the existing literature, while also being specific enough to avoid results outside the scope of the research.

2.3 INCLUSION CRITERIA

This systematic review included articles published between 2020 and 2025, written in English, and classified as original research articles or review papers. Additionally, studies directly related to the scope of this review were considered, namely, urban parks understood as green infrastructure, with a focus on sustainability, environmental justice, resilience, and community well-being.

2.4 EXCLUSION CRITERIA

Following PRISMA protocol criteria no. 5 and no. 7, articles that did not fall within the human and urban scope were excluded from the review, including those focused on biodiversity, fauna, microbiology, environmental chemistry, air quality, and soil and physicochemical studies. Studies with an exclusive focus on transportation, commuting, and mobility were also excluded, as were those adopting an excessively technical approach, such as physical modeling of urban heat islands or analyses of generic vegetation without a direct connection to urban parks. Studies presenting high thematic redundancy, characterized by repetitive findings and limited methodological innovation, were excluded to prevent overrepresentation of similar evidence in the final sample.

2.5 STUDY SELECTION PROCESS (PRISMA FLOW DIAGRAM)

Following PRISMA criterion no. 7 (Search Strategy), the previously defined search string was applied to the Scopus and Web of Science databases, resulting in 3,606 records with no restrictions applied at this stage. After applying the predefined eligibility criteria, 2,044 records were retained. Due to database export limitations, 1,615 records were successfully imported

into Rayyan and constituted the final dataset for screening. The detailed selection process is presented in Figure 2 (PRISMA flow diagram).

Table 2

Results from the databases with applied filters

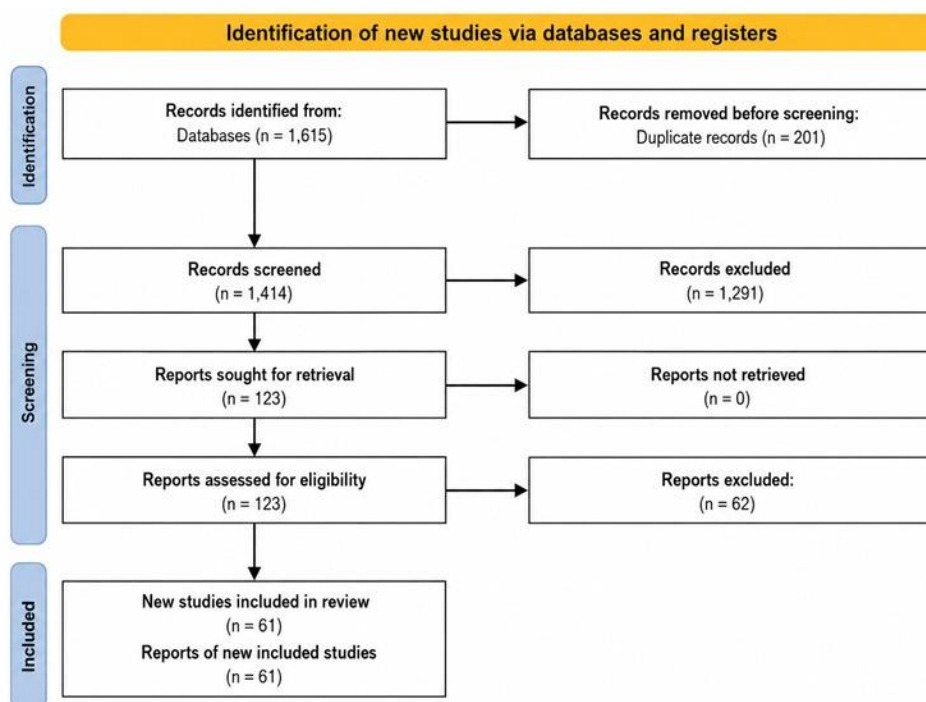
Name	Number of Documents	
	Before the Filter	After the Filter
Scopus	1143	615
Web of Science	2463	1429
Total	3606	2044

In accordance with PRISMA criterion no. 9 (Data Collection Process), which requires researchers to specify the methods used as well as any automation tools employed in the process, after the previous steps the database files in “.ris” format were imported into Rayyan, a web-based tool that supports the organization and screening of articles for systematic reviews. Using Rayyan’s automated detection tool, 402 potential duplicate records were identified, of which 201 were confirmed and removed prior to screening.

Subsequently, an initial screening was conducted based on titles and abstracts to assess thematic relevance, resulting in the exclusion of 123 documents that were not aligned with the research objectives.

In a new round of analysis, all abstracts were read in greater detail to verify alignment with the two main research terms and to assess the relevance of the documents. From this analysis, 62 documents were excluded.

In compliance with PRISMA criterion no. 11 (Study risk of bias assessment), which requires the specification of the methods used to assess the risk of bias in the included studies, and PRISMA criterion no. 12 (Effect measures), which calls for the specification of effect measures, the remaining 123 documents were subjected to full analysis. At this stage, documents that did not demonstrate a clear focus on the specific areas of study during full-text reading were excluded, resulting in a total of 61 documents included in the review.

Figure 2*PRISMA Analysis Flow Diagram***2.6 TOOLS AND SOFTWARE USED**

The main tools used in the research were Rayyan, employed for systematic screening, duplicate removal, and organization of the selection process; VOSviewer, used in the exploratory phase with the 123 articles identified prior to full-text reading to generate keyword co-occurrence maps, co-authorship networks, and thematic clusters, allowing visualization of the scope and initial structure of the research field; and Bibliometrix (R package), subsequently applied to the final sample of 61 articles for the execution of consolidated bibliometric analyses.

Within the R environment, Bibliometrix was used to generate 11 main outputs derived from the biblioAnalysis and biblioshiny functions, enabling quantitative and visual analyses of scientific production. The outputs generated were:

1. Annual scientific production chart (Annual Scientific Production) – evolution of the number of publications between 2020 and 2025;
2. Most relevant sources chart (Most Relevant Sources) – journals with the highest number of articles;
3. Most relevant authors chart (Most Relevant Authors) – researchers with the highest volume of publications;
4. Most local cited sources chart (Most Local Cited Sources) – the most influential journals within the sample;

5. Most local cited authors chart (Most Local Cited Authors);
6. Most global cited documents chart (Most Global Cited Documents);
7. Country scientific production map (Country Scientific Production);
8. Co-authorship network;
9. Treemap country/frequency – proportional visual representation of scientific production;
10. Co-occurrence network (Co-Occurrence Network) – basis for generating the Thematic Map and the Thematic Evolution Map).

These outputs made it possible to examine the intellectual and thematic structure of the field, identifying publication patterns, central authors, collaboration networks, thematic cores, and emerging trends.

Some graphical results were exported to Excel, where adjustments to scale, colors, and explanatory legends were applied, ensuring visual clarity and standardization across the figures presented. The Mendeley and Zotero software packages were used for reference management and organization, while Excel was also employed for spreadsheet systematization and consolidation of the final data.

Thus, the integrated use of Rayyan, VOSviewer, Bibliometrix, Mendeley, Zotero, and Excel ensured methodological rigor, reproducibility, and analytical consistency across all stages of the systematic review, from initial screening to the generation of graphics and the integrated interpretation of results.

2.7 METHODOLOGICAL SYNTHESIS

The applied methodology sought to combine quantitative rigor (bibliometrics, network analysis, and pattern analysis) and qualitative rigor (critical reading and conceptual systematization), thus ensuring a comprehensive view of trends, gaps, and future research directions on urban parks as green infrastructure.

3 RESULTS

The results of this research are organized into two main stages, corresponding to the methodological approaches applied. The first stage refers to the bibliometric review, in which publication patterns, co-authorship networks, and recurring terms in the literature were quantitatively analyzed. The second stage corresponds to the bibliographic review, which qualitatively synthesized and discussed the 61 selected articles, allowing the identification of the main dimensions, emerging themes, and conceptual gaps in the field of study on urban parks and sustainability.

3.1 BIBLIOMETRIC REVIEW

The bibliometric review stage was carried out through the construction and interpretation of bibliometric maps, using specific software to analyze term co-occurrence, author networks, and the temporal evolution of publications. This stage aimed to preliminarily address research questions (i) and (ii), related to the main dimensions and themes discussed in the literature on sustainable urban parks. In this process, a spatial analysis of authors' affiliations was also conducted, highlighting the geographic distribution of scientific production, as well as a classification analysis of the articles according to specific criteria, in order to organize the body of studies into comparable categories and generate relevant data for researchers interested in the topic.

3.1.1 Bibliometric Maps

In order to meet PRISMA protocol criterion no. 13 (Synthesis methods), bibliometric maps were developed, which are useful for organizing the research and supporting the identification of the current state of the topic addressed. For this analysis, a file containing the 123 studies selected in Rayyan was exported in .ris format and subsequently processed in the VOSviewer software.

At this stage, the minimum threshold was set to five occurrences. To create the maps, the options “create a map based on bibliographic data,” “read data from reference manager files,” and type of analysis: “co-occurrence” and “keywords” were selected, followed by the “full counting” option. A total of 50 terms were identified, of which the 35 most relevant terms were selected by VOSviewer. Prior to generating the map, some terms were excluded. These manual exclusions were applied to terms that did not represent the research focus, that is, terms that did not indicate study dimensions. The terms excluded at this stage were: “China,” “human,” “article,” “humans,” “male,” “spatial analysis,” “strategic approach,” “perception,” “adult,” “United States,” “decision making,” “housing,” “assessment method,” “Shanghai,” and “open space.” The results can be observed in Table 5, and the map with the list of keywords is presented in table 3:

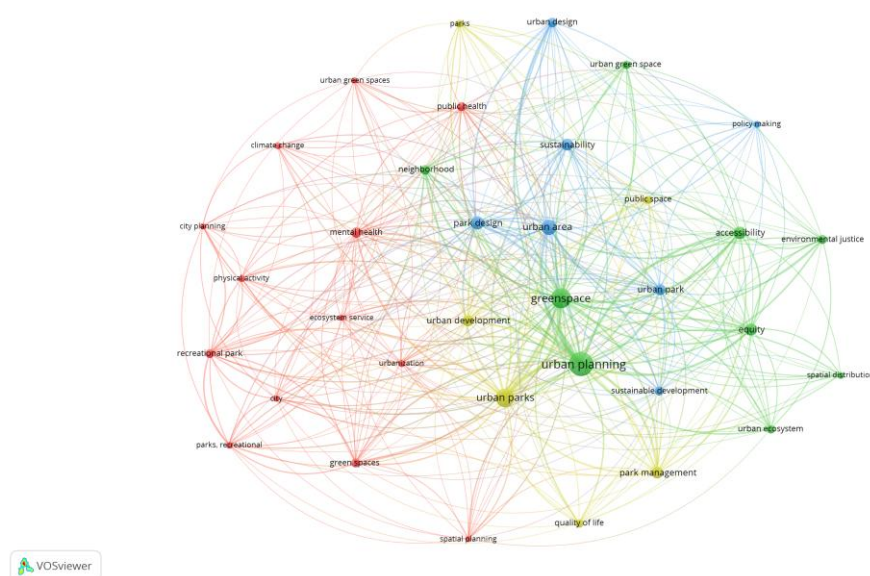
Table 3

Number of occurrences in the bibliometric map

Terms Threshold	Number of Terms to be deleted	Clusters	Group Cluster		N° Items	Links	Items
			N° Cluster	Color			
50	15	4	1	Red	13	403	35
			2	Green	9		
			3	Blue	7		
			4	Yellow	6		

Figure 3

Bibliometric map generated in VOSviewer



Bibliometric map generated in VOSviewer

The red cluster groups 13 items: city, city planning, climate change, ecosystem service, green space, mental health, parks recreational, physical activity, public health, recreational park, spatial planning, urban green spaces, and urbanization.

The green cluster, with 9 items, brings together: accessibility, environmental justice, equity, greenspace, neighborhood, spatial distribution, urban ecosystem, urban green space, and urban planning.

The blue cluster, with 7 items, includes: park design, policy making, sustainability, sustainable development, urban area, urban design, and urban park.

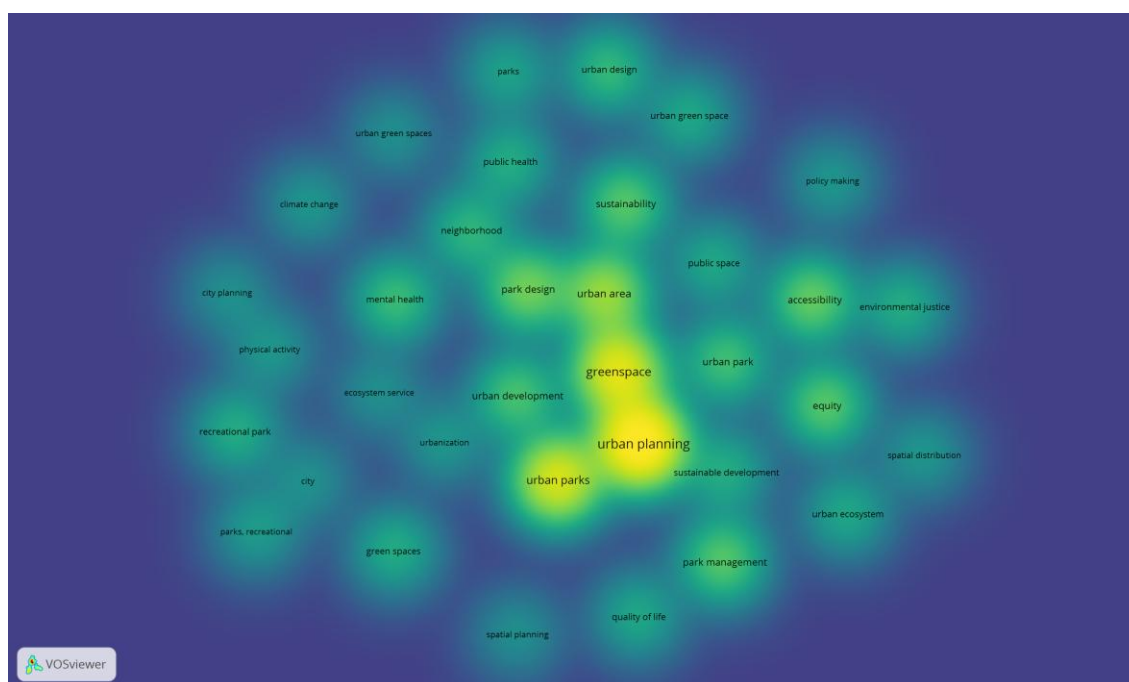
Overlay visualization chart generated in VOSviewer



In contrast, more recent terms, shown in yellow, highlight emerging trends such as equity, environmental justice, accessibility, policy making, and spatial distribution, which gained prominence in 2024. This indicates a shift in the focus of the literature, from the traditional debate on planning and health toward a more critical and inclusive approach that connects urban parks to issues of socioenvironmental justice, equity, and governance. In this way, the field is expanding and opening space for research that links green infrastructure with social participation and public policy.

Figure 5

Density visualization chart generated in VOSviewer



Analysis of the density visualization chart.

This chart highlights which themes are most frequently studied within the literature on urban parks and planning. The yellow areas represent topics that appear most often and occupy the center of the discussions, such as urban planning, greenspace, and urban parks. These concepts form the foundation of the field and serve as starting points for connecting research on health, quality of life, sustainability, and urban design.

As one moves away from the yellow areas, green and blue points appear, indicating themes that are present but still less explored. This is the case for environmental justice, equity, and policy making, which appear more peripheral but already connected to the core. This suggests that these topics are still gaining ground and represent research opportunities for scholars seeking to contribute new perspectives. Thus, the chart reveals both what is already consolidated and what is emerging as a promising path for future investigations.

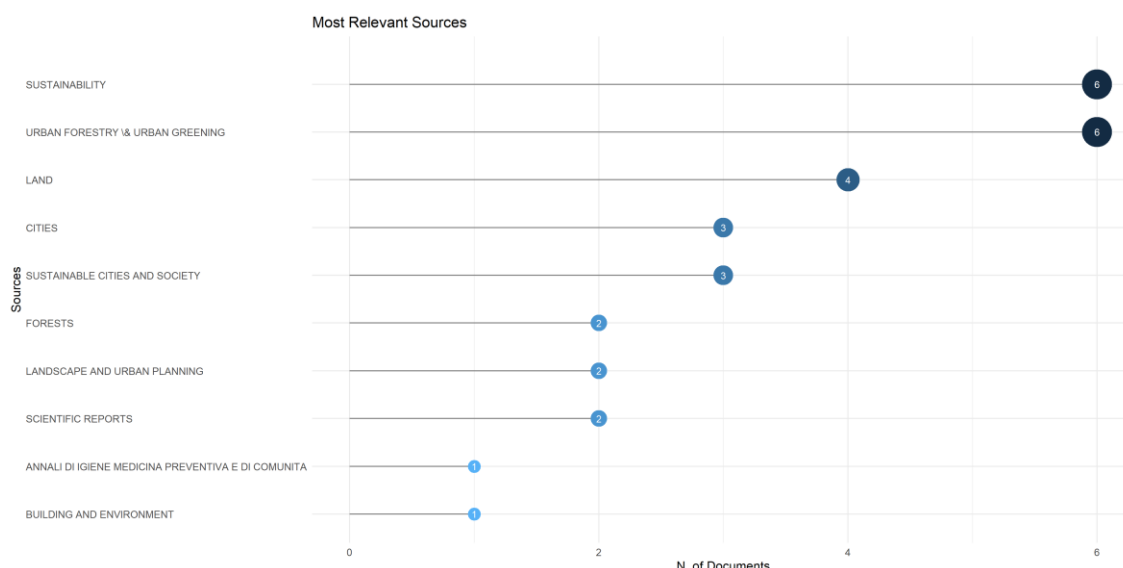
In accordance with PRISMA protocol requirements, questions (i) and (ii), related to the dimensions and main themes of the literature, were initially addressed. Based on the exploratory analysis conducted in VOSviewer (123 articles), it was preliminarily identified that research on sustainable urban parks is organized around five major dimensions: health and well-being; sociospatial equity and environmental justice; park quality and user experience; planning, management, and governance; and socioeconomic impacts and mobility. Within these dimensions, themes such as restorative effects on mental health, biophilic design and

multisensoriality, accessibility and inequalities of access, green gentrification, and civic participation stand out. These initial observations guided the refinement of the analysis in subsequent stages. In addition, the overlay visualization made it possible to observe both themes that are already consolidated in the literature and those emerging as new research trends, highlighting the role of VOSviewer as an essential exploratory step for structuring the field and guiding in-depth investigation of the selected articles.

3.1.2 Bibliometric analysis of the 61 selected articles

After consolidation of the final sample, a bibliometric analysis of the 61 selected articles was conducted using the Bibliometrix software. This stage aimed to identify publication patterns, the most relevant journals, the most productive authors, co-authorship networks, and the temporal evolution of research on sustainable urban parks. The results were organized into charts and tables, allowing observation of both the concentration of scientific production in specific journals and the recent growth of interest in the topic. The findings of this analysis are presented in graphical form, accompanied by interpretation, and allow a more specific response to questions (i), (ii), and (iii) of the PRISMA protocol, serving as a bridge to the qualitative discussion in the following chapter.

Figure 6
Most Relevant Sources



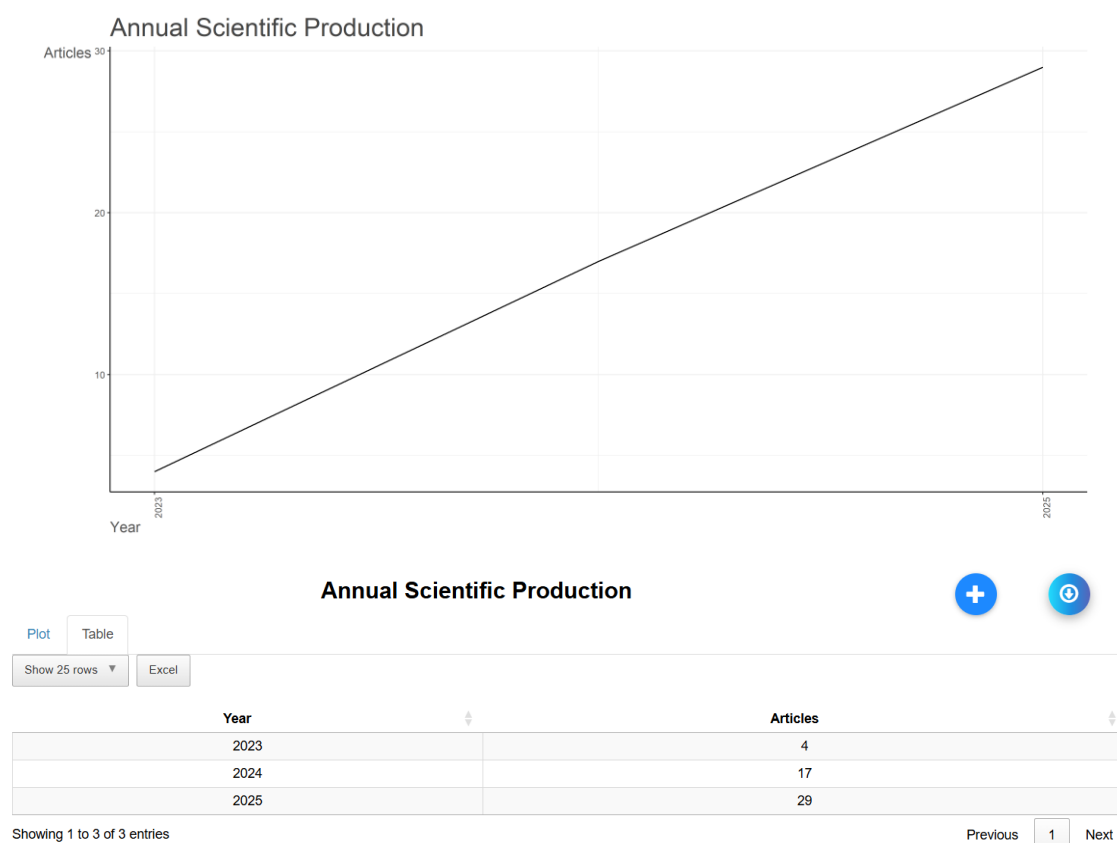
This graph shows which journals published the largest number of articles on the topic within the analyzed database. The x-axis presents the names of the journals, and the y-axis indicates the number of articles identified in the analyzed data. The journals with the highest

number of publications were Sustainability and Urban Forestry & Urban Greening, with six articles each, followed by Land with four articles, and Cities and Sustainable Cities and Society, each with three articles on the topic. The remaining journals had fewer publications (two or one article).

This highlights that the scientific discussion is concentrated in a small number of strategic journals, which function as the main vehicles for disseminating research on the topic.

Figure 7

Annual Scientific Production

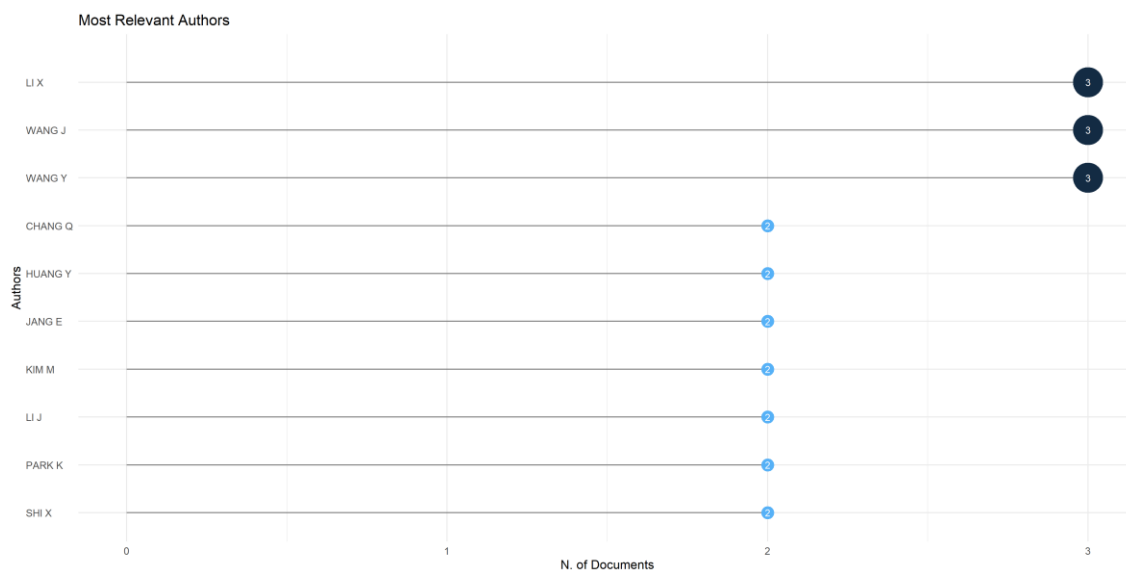


A significant growth in scientific production on the topic can be observed, increasing from only four articles in 2023 to 17 in 2024 and reaching 29 in 2025.

This increase demonstrates that the field has been gaining relevance and attracting greater interest from the academic community in recent years, indicating an expanding field in the process of consolidation.

Figure 8

Most Relevant Authors

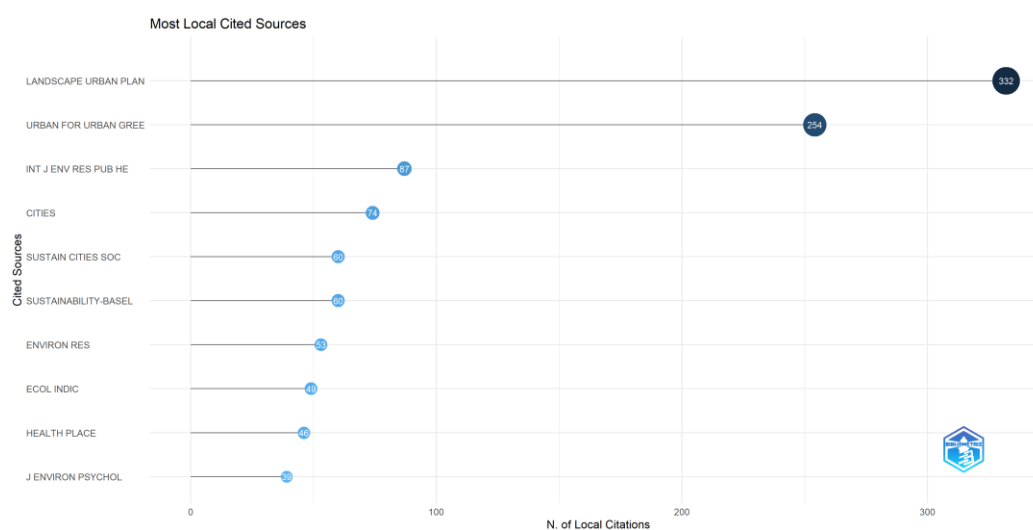


The most productive authors identified in the field were Li X, Wang J, and Wang Y, each with three articles. Following them, a group of researchers (Chang Q, Huang Y, Jang E, Kim M, Li J, Park K, and Shi X) appears with two publications each. This demonstrates that there is a diverse network of authors contributing to the field, without concentration on a single researcher.

This scenario reveals a broad network of contributions, without the predominance of a single scholar, suggesting plurality and collaboration in the development of the field.

Figure 9

Most Local Cited Sources

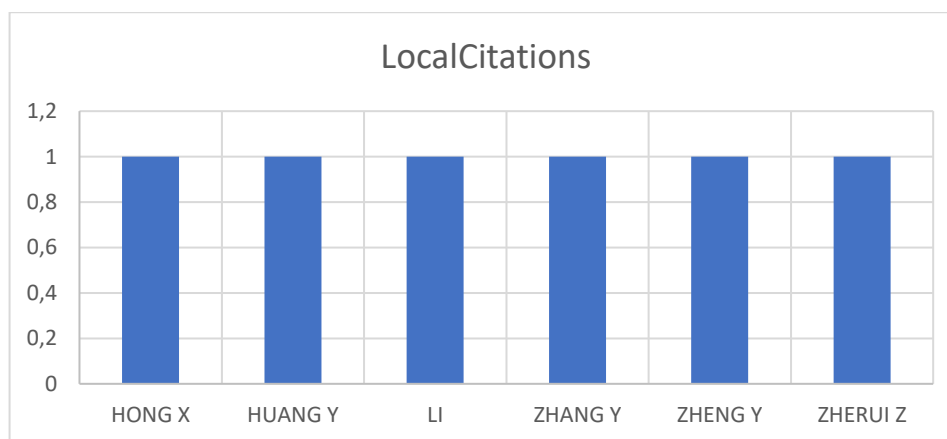


The most locally cited sources were Landscape and Urban Planning (332 citations) and Urban Forestry & Urban Greening (254), followed by the International Journal of Environmental Research and Public Health (87) and Cities (74). These journals are established as central references in the field, supporting the theoretical and methodological foundations that guide studies on urban parks and sustainability.

These journals exert strong influence within the literature, positioning themselves as core references for researchers in the field.

Figure 10

Most Local Cited Authors

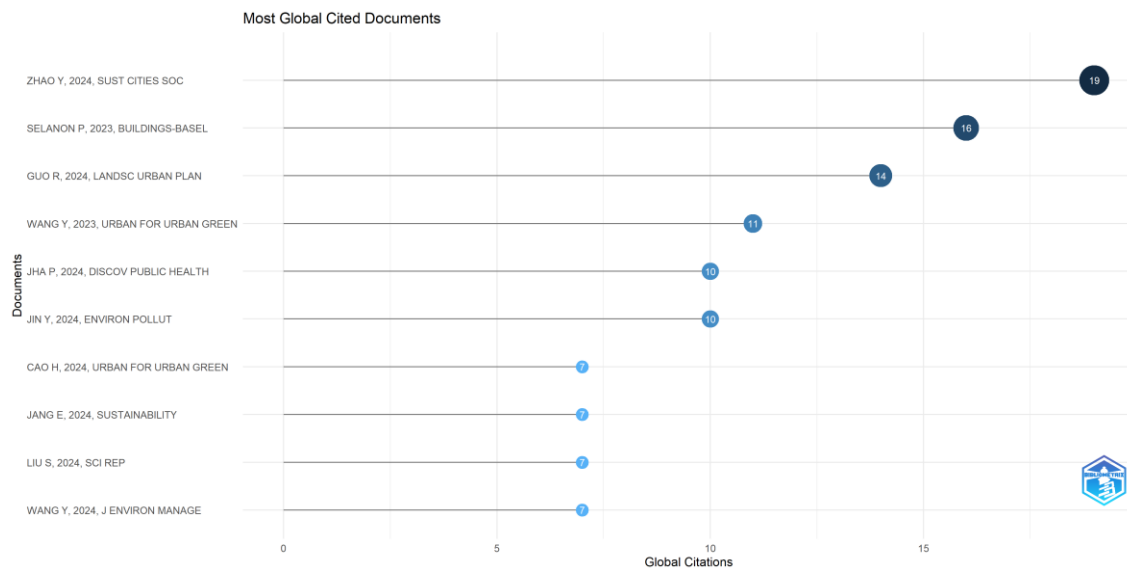


The analysis of local author citations shows that the names Hong X, Huang Y, Li, Zhang Y, Zheng Y, and Zherui Z appear sporadically, each with one citation. This indicates that, within the analyzed set, there is no predominance of a single widely cited author, but rather a balanced distribution of references among different researchers.

This demonstrates that, within the analyzed corpus, there is no broadly dominant author, but instead an even distribution of references across multiple scholars.

Figure 11

Most Global Cited Documents



The analysis of the most globally cited documents shows that the article by Zhao Y (2024), published in Sustainable Cities and Society, was the most influential, with 19 citations. This is followed by Selanon P (2023), published in Buildings–Basel (16 citations), and Guo R (2024), in Landscape and Urban Planning (14 citations). These results demonstrate that studies published in internationally high-impact journals have exerted greater influence on the dissemination of knowledge on the analyzed topic.

These results demonstrate that articles published in high-impact international journals have greater diffusion power and are fundamental to consolidating the research field.

Figure 12

Country Scientific Production

Country Scientific Production

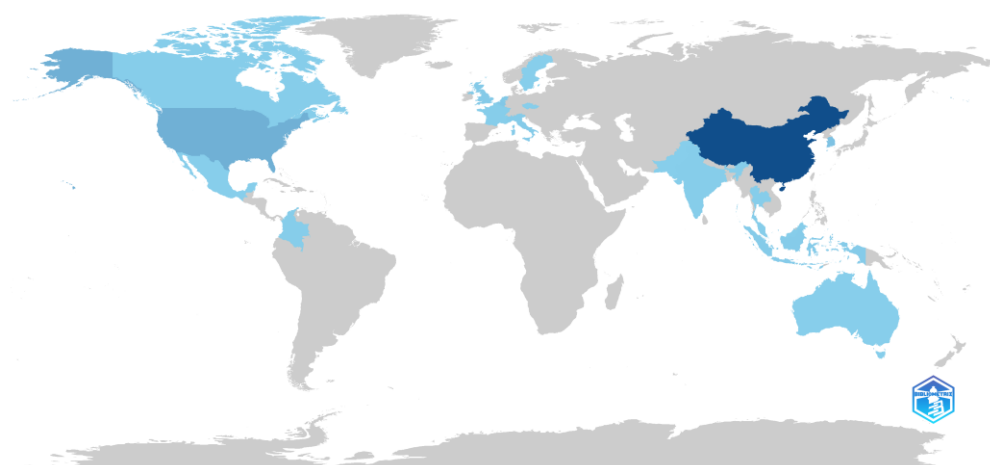
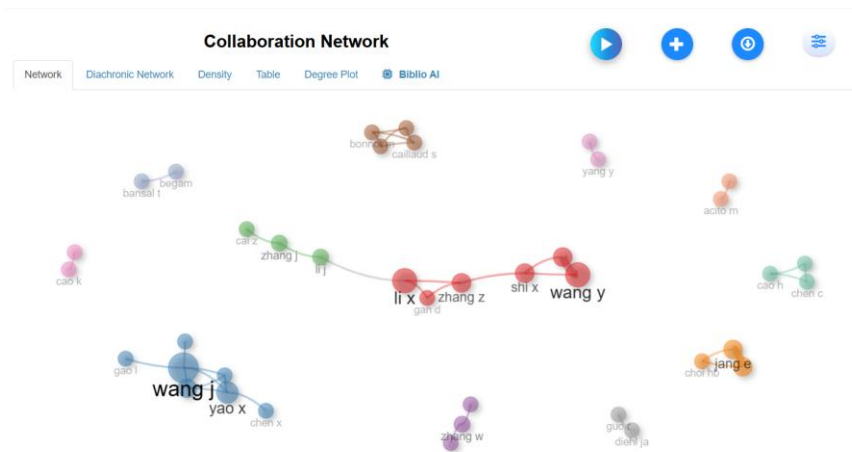


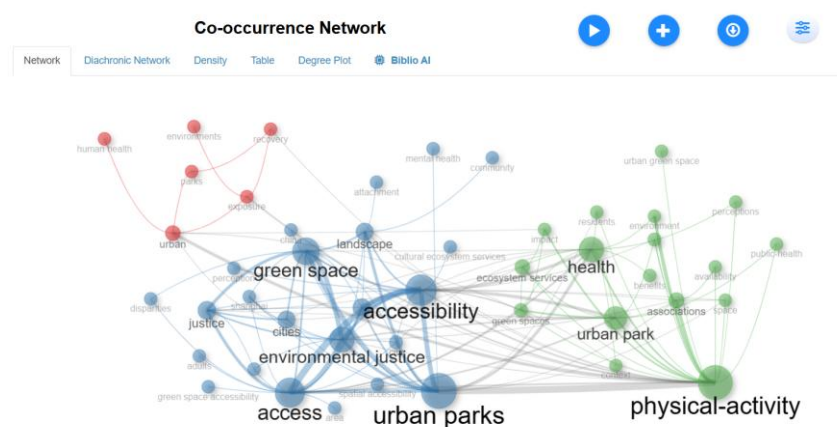
Table 4*Frequency of publications by country (2020–2025)*

Country	Freq
CHINA	106
USA	24
SOUTH KOREA	10
BELGIUM	6
NETHERLANDS	5
UK	4
INDONESIA	3
ITALY	3
CANADA	2
COLOMBIA	2
FRANCE	2
INDIA	2
MALAYSIA	2
THAILAND	2
AUSTRALIA	1
CZECH REPUBLIC	1
MEXICO	1
PAKISTAN	1
SINGAPORE	1
SWEDEN	1

The country scientific production map (Figure 12) uses shades of blue to indicate the intensity of publications. Countries shown in darker blue, such as China (106 articles) and the United States (24 articles), stand out for their leadership in academic production on sustainable urban parks. Intermediate shades of blue represent nations with moderate output, such as South Korea (10 articles), Belgium (6 articles), and the Netherlands (5 articles). Lighter shades indicate more limited contributions, exemplified by Latin American countries such as Colombia (2 articles) and Mexico (1 article). Finally, countries shown in gray did not present records during the analyzed period, reinforcing the regional concentration of the scientific literature.

Figure 13*Co-Authorship Network*

The co-authorship network reveals the formation of distinct clusters of scientific collaboration. Notable groups include those led by Li X and Wang Y (red cluster) and by Wang J and Yao X (blue cluster), which display high centrality and act as connecting nodes among researchers. These findings indicate well-defined research hubs in which certain authors assume strategic roles in knowledge diffusion.

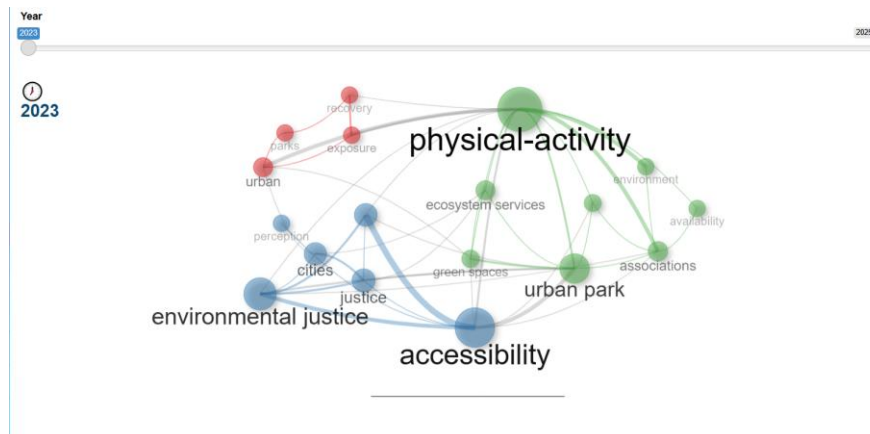
Figure 14*Co-occurrence Network*

The analysis of the co-occurrence network shows that research on urban parks is organized around three interconnected axes: accessibility and socioenvironmental justice (blue), health and ecosystem services (green), and the urban environment and human health

(red). Urban parks act as a central node that integrates these themes, revealing parks as multifunctional spaces oriented toward health, social equity, and environmental sustainability.

Figure 15

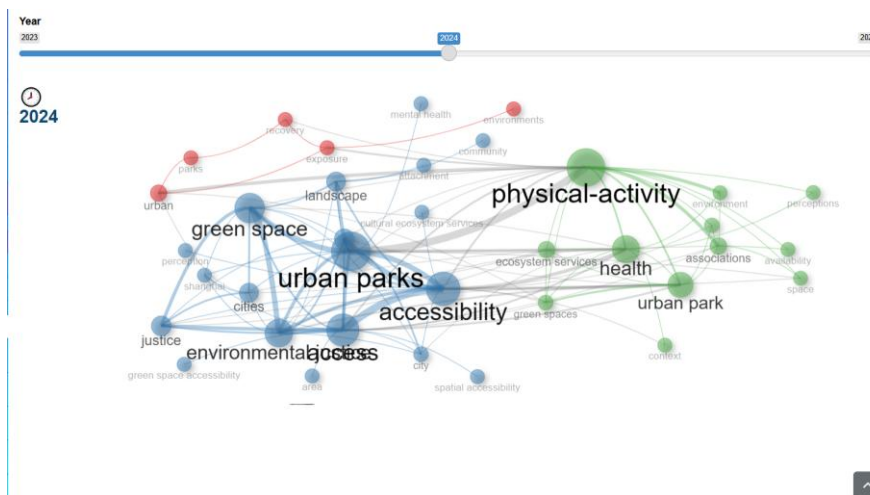
Temporal analysis - 2023



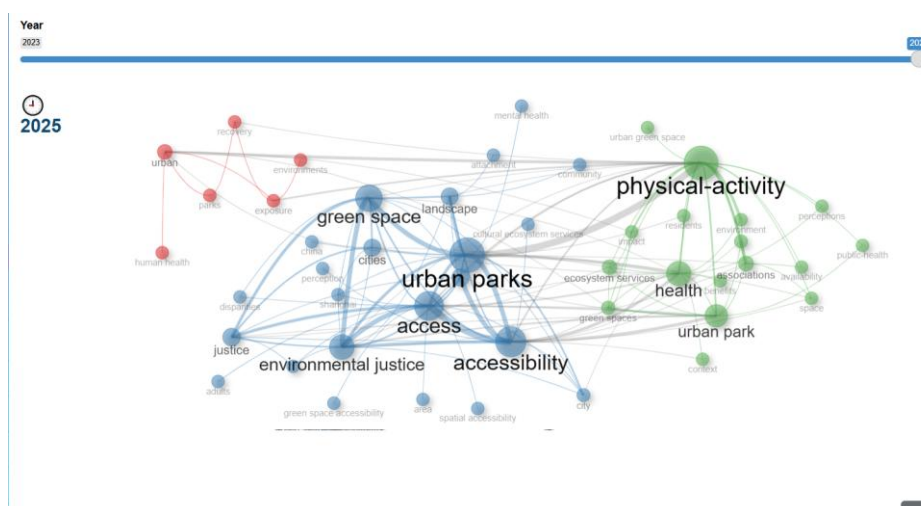
In 2023, the research was organized into three main thematic groups: physical activity, environmental justice, and accessibility. During this period, there was limited integration between social and environmental dimensions.

Figure 16

Temporal analysis - 2024.

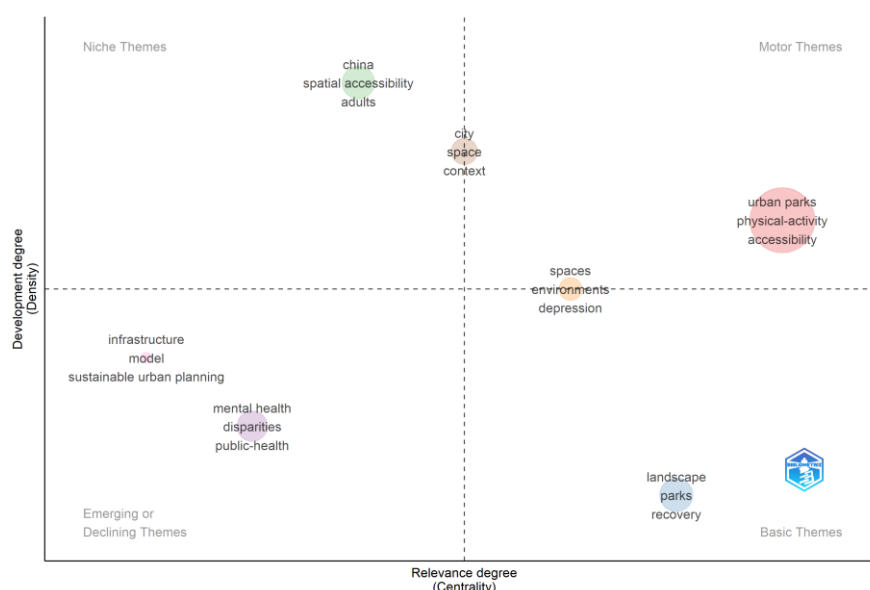


In 2024, a greater integration among the clusters can be observed, with a strengthening of the terms urban parks, green space, and health. The emergence of the theme of mental health in the blue cluster is also noted.

Figure 17*Temporal analysis - 2025.*

In 2025, consolidation of the field can be observed, with urban parks at the center of the discussions, articulating accessibility, environmental justice, and health benefits linked to physical activity. The term human health also appears, emphasizing benefits to human health associated with exposure to the environment.

In summary, the temporal analysis highlights the maturation and consolidation of the field of studies on urban parks between 2023 and 2025. Research evolves from isolated approaches to an integrated perspective, in which parks are understood as essential infrastructure for human health, socioenvironmental equity, and urban sustainability. This trajectory reinforces the growing importance of urban parks as strategic spaces for social inclusion, well-being, and adaptation to climate change.

Figure 18*Thematic Map*

The Thematic Map, generated from the analysis of keyword co-occurrence in Bibliometrix, organizes the themes of the literature into four quadrants that reflect the degree of development (density) and relevance (centrality) of each cluster. Accordingly, the themes are classified as Motor Themes (well developed and central), Basic Themes (structuring but weakly developed), Niche Themes (highly developed but peripheral), and Emerging/Declining Themes (still underexplored or in decline). This graphical representation makes it possible to identify both consolidated areas and gaps and opportunities for future investigation in the study of urban parks.

Table 5*Detailed legend of the Thematic Map (Bibliometrix)*

Cluster / Color	Keywords (with frequency)
Motor Themes (red)	urban parks (16); physical-activity (14); accessibility (12); access (11); green space (11); health (10); urban park (10); environmental justice (8); cities (6); equity (6)
Basic Themes (blue)	landscape (6); parks (6); recovery (3); attachment (2); community (2); happiness (2); motivation (2); preference (2)
Niche Themes (green)	China (3); spatial accessibility (3); adults (2); area (2); green space accessibility (2); health-care (2); people (2); preferences (2); scale (2); service (2)
Niche Themes (brown)	city (5); space (3); context (2); index (2); urban green spaces (2); vegetation (2)

Emerging/Declining Themes (lilac)	mental health (4); disparities (3); public-health (3); urban green space (3); income (2); obesity (2); proximity (2); public health (2)
Tema intermediário (orange)	spaces (4); environments (3); depression (2); mortality (2); urbanization (2)
Tema de transição (light orange)	spaces (4); environments (3); depression (2); mortality (2); urbanization (2)

The Emerging/Declining Themes quadrant highlights topics such as mental health, disparities, public health, and sustainable urban planning, which, although still showing low density and centrality in the literature, emerge as promising areas for new investigations. These results suggest that the relationship between urban parks, mental health, and sociospatial inequalities remains underexplored, but is likely to gain relevance in the context of contemporary cities, especially after the COVID-19 pandemic, which intensified discussions on psychological well-being in urban environments.

At the same time, the marginal positioning of themes related to sustainable urban planning and health equity indicates the need to deepen studies that frame urban parks not only as leisure spaces, but as critical infrastructure for promoting public health, mitigating social vulnerabilities, and building more inclusive cities. In this way, a research agenda is opened that can contribute both to the theoretical advancement of the field and to the development of public policies guided by socioenvironmental justice and urban resilience.

3.2 BIBLIOGRAPHIC REVIEW

In the classificatory analysis stage, each article was organized according to specific relevance criteria, in line with PRISMA protocol criterion no. 13 (Synthesis methods). The initial search resulted in 1,414 articles, from which those not directly related to the human and urban theme were excluded in a first filter, such as studies on biodiversity, microbiology, environmental chemistry, or sectors unrelated to urban planning. Subsequently, only studies that directly addressed urban parks as green infrastructure, nature-based solutions, climate change, resilience, and socioenvironmental justice were retained, reducing the set to 123 articles. This initial sample was exported to Rayyan, where titles and abstracts were read, and duplicates and tangential articles were removed.

The analysis revealed a strong concentration of publications in a small number of journals, notably Sustainability (Switzerland) (17 articles), Land (10 articles), and Urban Forestry and Urban Greening (10 articles), followed by Cities and Sustainable Cities and Society (five articles each) and Landscape and Urban Planning (four articles). Although the first two

journals show a high volume of publications, priority was given to studies with greater methodological rigor and stronger alignment with the objectives of this review. In contrast, highly prestigious journals such as *Landscape and Urban Planning* and *Sustainable Cities and Society* were prioritized due to their consistency and scientific relevance.

To ensure analytical consistency, studies presenting high thematic redundancy, repetitive findings, or limited methodological contribution were excluded, preventing the overrepresentation of similar evidence in the final sample. This refinement process consolidated the sample into 61 final articles, representing international diversity and strong alignment with the research objectives. Thus, the classificatory analysis made it possible to reduce redundancy, ensure methodological balance, and retain studies that effectively supported the subsequent stage of bibliographic analysis and the response to the research questions.

Based on this set of 61 selected and analyzed articles, the following discussion stage interprets the results in light of the guiding questions of the PRISMA protocol, highlighting trends, gaps, and future directions in the literature.

4 DISCUSSION

The discussion stage aims to integrate the results of the bibliometric analysis with the reviewed literature, systematically responding to the guiding questions established by the PRISMA protocol. To support this stage, a table containing the 61 final selected articles was prepared and is presented as an appendix, compiling the title, objective, methodology, and main results of each study. This systematization made it possible to organize comparisons, highlight patterns, and identify gaps in a clear and consistent manner, serving as the empirical basis for the critical interpretation of the findings.

Based on this set of articles, and in accordance with the established objectives, the responses to the questions formulated at the beginning of the research are presented below.

4.1 MAIN DIMENSIONS OF RECENT RESEARCH

Based on the 61 articles systematized in the table presented in the appendix, it was possible to identify that recent literature on sustainable urban parks is concentrated around five major dimensions. The first is health and well-being, with studies showing that parks contribute to both physical and mental health by providing spaces for psychological restoration, stress reduction, and the promotion of physical activity [2][41][42]. The second dimension is sociospatial equity and environmental justice, which involves the analysis of accessibility, territorial distribution, and differentiated access for vulnerable groups, such as older adults,

children, and low-income populations [14][16][35][43][44]. A third dimension concerns park quality, design, and user experience, considering biophilic aspects, multisensory elements, and types of facilities that encourage different forms of use [1][15][20][30]. Another relevant dimension is planning, management, and governance, including co-design practices, citizen participation, and management evaluation methods [45][46][47][48][49]. Finally, there is a focus on socioeconomic impacts and urban mobility, which address visitation patterns, preferences for local parks, and the effects of processes of environmental gentrification [5][32].

4.2 MAIN THEMES DISCUSSED WITHIN THESE DIMENSIONS

Critical reading of the articles listed in the table shows that, within these dimensions, the main themes include the restorative effects of parks on mental health and the positive association between contact with nature and the reduction of symptoms related to stress and chronic diseases [9][20][41]. In addition, the contribution of green spaces to social vitality is emphasized. In this context, satisfaction with green spaces in the residential environment shows a consistent positive relationship with subjective well-being, indicating that neighborhood green areas and private gardens may exert an influence equal to or even greater than that of urban parks, including through indirect effects associated with perceptions of local greenery [50].

Equity has been discussed based on the observation that children and older adults often face barriers to access, as do low-income groups and ethnic minorities [14][51][52][53]. Studies on quality and user experience emphasize how biophilic design, sensory elements, thermal comfort, and recreational facilities can enhance attractiveness and encourage different patterns of use [1][54]. Inequalities related to recreational opportunities tend to be more visible than those associated with environmental quality, indicating that the unequal distribution of facilities and recreational functions contributes to the formation of privileged urban areas and underserved ones, even in contexts of generally good environmental quality [55].

In the field of management, debates focus on how to integrate digital tools, participatory methodologies, and quality indicators capable of balancing efficiency and social inclusion [3][56]. In the socioeconomic dimension, the most recurrent theme is green gentrification, which emerges as a dilemma between expanding green infrastructure and avoiding the displacement of lower-income residents [32].

4.3 METHODOLOGIES AND ANALYTICAL TOOLS APPLIED

The methodologies employed range from advanced spatial analyses, such as the 2SFCA method, geographically weighted regressions, and inequality indices [57] [51], to big data–

based approaches, which use mobile phone data, social media, and artificial intelligence to map visitation patterns [16][46][46][58]. Multisensory analysis tools, such as EEG and heart rate measurements, have also been applied to understand psychophysiological responses to the environment [10]. Structured questionnaires, interviews, and participatory mapping complement the qualitative dimension, revealing the perceptions of users and managers [15][59][60]. Systematic reviews and meta-analyses have been used to synthesize evidence, while composite indices, such as ParkScore, seek to integrate dimensions of quality, access, and equity [61][62][63]. Despite methodological sophistication, fragmentation is still observed: few studies consistently integrate health, equity, and user experience.

4.4 CONCEPTUAL AND METHODOLOGICAL GAPS

Despite the advances, important gaps remain. First, there is a lack of longitudinal studies capable of demonstrating causality between the presence of parks and the observed effects on health and social inclusion. There is also a noticeable absence of integrated approaches that combine space quality, sociospatial justice, and health outcomes in a standardized and comparable way across different cities. Another critical issue is the limited attention given to neurodivergent populations, such as children diagnosed with autism, ADHD, and other neurodevelopmental disorders. Although the literature recognizes the role of parks for children in general [64], there are very few investigations that explore how outdoor environments can mitigate excessive screen exposure, reduce sensory overload, and promote specific benefits for the well-being and cognitive development of neurodivergent groups. This gap points to the need to expand the notion of equity beyond age-based and socioeconomic categories, also incorporating mental health conditions and neurodiversity.

4.5 FUTURE RESEARCH DIRECTIONS AND PROMISING AGENDAS

Future research agendas may prioritize longitudinal studies and impact evaluations that track park interventions over time [19], allowing for the understanding of changes in physical and mental health, usage patterns, and urban transformations. Another promising direction is the development of integrated indices that combine environmental quality, sociospatial justice, and health benefits, in order to support more consistent public policies [22]. In this context, the case of Chengdu (2025) shows that the application of quantitative green equity indicators, such as the Theil Index combined with spatial optimization models, can guide the reorganization of the distribution of urban parks, helping to address inequalities that persist even with the expansion of green areas [65]. There is also a need to develop urban planning strategies that

link park creation with housing policies, avoiding green gentrification and promoting the permanence of vulnerable populations [36]. Beyond this, an innovative field of investigation opens up by considering the role of parks for children and youth with neurodivergent diagnoses. Studying how outdoor areas can become healthy alternatives to excessive screen time, how they can contribute to reducing stress symptoms, and how they can foster sensory and social inclusion represents a relevant pathway. The co-design of parks with the participation of families, educators, and health professionals may result in more inclusive urban environments, capable of responding to the growing number of diagnoses and demands related to autism and other neurodevelopmental conditions.

5 CONCLUSIONS

The present study aimed to critically analyze the international literature on urban parks as green infrastructure, with a focus on the dimensions of sustainability, environmental justice, and community well-being. The research sought to answer five guiding questions: (i) which dimensions are addressed by recent research on sustainable urban parks; (ii) what are the main themes discussed within these dimensions; (iii) which methodologies and analytical tools have been applied; (iv) which conceptual and methodological gaps remain in the literature; and (v) which future research directions can be suggested.

The investigation was conducted in accordance with the PRISMA 2020 protocol, using the Scopus and Web of Science databases, recognized for their scientific rigor and broad coverage. The methodological process involved two complementary stages: a bibliometric review, supported by the tools Rayyan, VOSviewer, Bibliometrix, Mendeley, Zotero, and Excel, aimed at organizing and quantitatively analyzing scientific production; and a bibliographic review of a qualitative nature, focused on the conceptual and theoretical interpretation of the selected studies.

The combination of the terms “urban park,” “sustainability,” “urban planning,” “smart city,” and “environmental justice” proved appropriate for retrieving representative studies in the field, allowing the identification of consistent thematic and theoretical patterns. This search strategy made it possible to obtain a corpus of 61 articles, which provided a solid basis for answering the proposed questions and mapping the main research trends.

The results indicate that recent scientific production on urban parks is structured around five main dimensions: health and well-being; sociospatial equity and environmental justice; park quality and user experience; planning and governance; and socioeconomic impacts and mobility [66]. Within these dimensions, themes such as the restorative effects of nature,

accessibility, green gentrification, participatory planning, and the integration of parks into urban sustainability policies stand out. The expansion of the field in recent years is also evident, with significant growth between 2023 and 2025, particularly in well-established international journals. However, theoretical and methodological gaps persist, including the scarcity of longitudinal studies and the limited attention given to neurodivergent populations, which remain underrepresented in discussions of inclusion and equity in green spaces.

During the development of this study, challenges were identified in the standardization and refinement of keywords, a process that required successive combinations and adjustments to ensure precision and comprehensiveness in the search. This experience reinforced the importance of terminological consistency and the use of controlled descriptors in systematic reviews, in order to enhance the quality and reproducibility of scientific research.

This research acknowledges limitations related to the temporal scope (2020–2025) and language restriction (English-language articles), which may have excluded relevant contributions from other regions and languages. In addition, a methodological challenge was the selection and combination of keyword groups, whose definition required successive testing until a set of descriptors capable of accurately reflecting the scope and objectives of the research was achieved. Even so, the study provides a comprehensive and up-to-date synthesis of the topic, offering valuable inputs for public policies and for the expansion of the research agenda. Future investigations are recommended to incorporate longitudinal analyses, interdisciplinary approaches, and integrated indicators of environmental quality, equity, and health, as well as to expand the focus to underrepresented population groups, such as people with disabilities and neurodivergent individuals. Further research is also suggested on sensory and inclusive planning of urban parks, considering parks not only as leisure spaces, but as essential infrastructure for public health, social cohesion, and climate resilience.

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APPENDIX

Table 6

Studies Included in the Systematic Review

TITLE	YEAR	GOAL	METHODOLOGY	RESULTS
1 Park use patterns and park satisfaction before and after citywide park renovations in low-income New York City neighborhoods	2025	The objective of the study was to evaluate the impact of the <i>Community Parks Initiative (CPI)</i> park renovation program in New York City, analyzing changes in use patterns and satisfaction among residents of low-income neighborhoods in relation to parks.	Cross-sectional surveys applied to residents of neighborhoods near 31 parks undergoing renovation and also in 21 parks in socio-demographically comparable control neighborhoods. Interviews were conducted before and after the park renovations.	The renovations increased park use time and residents' satisfaction regarding the quality of facilities. The study shows that park renovation is an effective urban planning strategy, strengthening community support and public health.
2 Could there be negative sentiments toward urban parks? An analysis of internal and external factors	2025	To investigate negative sentiments associated with urban parks and to identify internal and external attributes that contribute to such perceptions.	Analysis of 83 urban parks in Nanjing using natural language processing techniques applied to Weibo posts, and multiple linear regression to analyze the relationship between park characteristics and negative sentiments.	Significant relationships were identified between physical attributes, visual landscape quality, accessibility, built environment density, park management, and negative public sentiments, providing insights for planning and management focused on emotional well-being.
3 Multisensory interactions in urban parks: Auditory-olfactory effects on psychophysiological responses of hypertensive elderly adults	2025	To investigate how auditory-olfactory interactions in urban parks influence the psychophysiological responses of elderly individuals with hypertension, providing evidence for the design of urban spaces that promote health.	Three parks in Xi'an, China, were selected to create distinct auditory and olfactory environments. Subjective perceptions, physiological parameters, and electroencephalogram (EEG) signals of elderly individuals were evaluated, stratified into two groups: high pulse pressure (HPP) and normal pulse pressure (NPP).	Auditory-olfactory stimuli improved comfort and reduced blood pressure, with distinct effects between the HPP and NPP groups; EEG results showed greater sensitivity in the HPP group.

4	Identifying older adults' needs for park renewal in low-income neighbourhoods: A citizen science approach	2025	To investigate the needs and preferences of older adults regarding urban park use and to explore how participatory processes can support park redesign to promote healthy aging.	Participatory park design study with older adults from low-income neighborhoods in Belgium, using three stages: citizen science action groups, walk-along interviews, and focus group interviews.	Older adults prioritized higher benches with armrests, accessible and safe pathways, a variety of exercise equipment, shaded and sheltered areas, vegetation diversity, and the presence of water resources. The participatory process proved relevant for informing future urban planning projects and policies.
5	Green Gentrification and Urban Parks: Exploring the Complex Dynamics of Commercial Transformation	2025	To investigate the role of new urban parks in commercial gentrification in Shanghai, an aspect that has been little explored in the debate on the socioeconomic effects of green spaces.	Application of a difference-in-differences (DID) model to analyze 2019 data in an area of 6,340.5 km ² , examining the relationship between the implementation of new urban parks and the growth of businesses associated with gentrification (such as exotic restaurants and cafés).	New urban parks in Shanghai stimulated businesses linked to gentrification, especially restaurants and cafés, with stronger effects in central areas and major parks. The study warns of unintended impacts, highlighting the need for urban planning that promotes health and socioeconomic equity.
6	Assessment of Spatial Equality and Social Justice of Urban Park Distribution from Park Category Perspective: Evidence from Shanghai, China	2025	To develop a geospatial–quantitative framework that integrates spatial metrics and social justice to evaluate equitable access to urban parks in high-density areas.	Application of the framework in the Xuhui District, Shanghai, analyzing the spatial distribution of parks, differentiated social demands (older adults, youth, and low-income populations), and inequalities among park types.	Spatial inequality was identified, with large parks concentrated in peripheral areas and shortages in dense central areas. Priority groups faced greater deficits in social justice, and small parks showed the worst disparities. The study recommends prioritizing social demands and investing in small-scale community parks.

7	Examining the Relationship Between Urban Park Quality and Residents' Health in South Korean Cities Using Public Data	2025	To investigate the relationship between the quality of urban parks and health indicators among 85 cities in South Korea, using a localized version of the ParkScore index—a metric internationally created by the Trust for Public Land (TPL) that evaluates park systems considering area, accessibility, investment, amenities, and equity.	Application of a localized version of the ParkScore index, considering five dimensions (area, amenities, investment, accessibility, and equity). Rates of mental health disorders (anxiety, depression, insomnia, ADHD, and schizophrenia) and obesity were analyzed using Pearson correlation.	Parks with greater accessibility showed a significant negative correlation with mental health disorders, especially depression and anxiety. Although the study is cross-sectional and limits causal inferences, the findings confirm the importance of urban parks for mental well-being and highlight the need for equitable, data-driven management policies.
8	Assessing accessibility and environmental equity in the context of sustained aging: Pathways for age-friendly urban park planning	2025	To develop a method to optimize accessibility to urban parks, considering the specific needs of older adults and promoting health and well-being in contexts of rapid population aging.	Development of a weighted model of park attractiveness based on older adults' preferences, incorporating travel impedance (walking time and public transport). Accessibility was assessed through multidimensional quantitative analysis, and a dynamic population projection model was used to simulate future demands.	Disparities in attractiveness were identified among different parks, revealing failures in the equitable distribution of resources. The study proposes long-term planning strategies for age-friendly urban parks, reinforcing their importance for quality of life and environmental equity in high-density cities.
9	Park quality and chronic disease: A city-level analysis	2025	To investigate the relationship between the quality of urban parks (measured by the ParkScore index) and the prevalence of chronic diseases in major U.S. cities.	Analysis of 93 cities between 2017 and 2019 using mixed-effects regression models. ParkScore, which integrates dimensions of area, amenities, investment, accessibility, and equity, was associated with age-adjusted prevalence of eight chronic diseases.	Significant negative correlations were found between ParkScore and four chronic diseases (hypertension, cancer, coronary heart disease, and COPD). No associations were found with diabetes, obesity, chronic kidney disease, or stroke. Sociodemographic variables also strongly influenced disease prevalence. The study reinforces the role of high-quality parks as essential urban infrastructure for chronic disease prevention.

10	Does perceived biophilic design contribute to human well-being in urban green spaces? A study of perceived naturalness, biodiversity, perceived restorativeness, and subjective vitality	2025	To examine how perceived biophilic design (PBD)—an approach that integrates natural elements and biodiversity into urban environments to promote well-being—and perceived restorativeness in urban parks influence visitors' subjective vitality, focusing on the mediating roles of perceived naturalness and perceived biodiversity.	Application of 1,177 questionnaires (1,133 valid) across four types of urban parks in China (ecological parks, inclusive children's parks, sports parks, and open spaces). Correlation and path analyses were used to evaluate relationships among perceived biophilic design (PBD), perceived naturalness, perceived biodiversity, perceived restorativeness, and subjective vitality.	Ecological parks were rated higher in naturalness, while open spaces showed lower perceived biodiversity. These factors, together with perceived restorativeness, increased visitors' subjective vitality and reinforced the biophilic value of urban planning in promoting psychological health and well-being.
11	Analyzing the Mismatch Between Urban Park Supply and Community Needs in Busan: A Public Health Perspective	2025	To assess spatial disparities between the supply and demand of urban parks in Busan, South Korea, considering socioeconomic indicators and environmental justice.	Quantitative GIS-based approach, dividing the city into 100 m × 100 m grids. A modified Huff model—an accessibility-based spatial analysis tool—was used to estimate the probability of park use considering park attractiveness (size/quality) and distance decay (β) to calculate park supply in relation to the standard of 6 m ² per person. These results were overlaid with a composite need index composed of six socioeconomic indicators.	Of the 205 communities in Busan, 100 lacked green areas; after integrating socioeconomic factors, 62 communities remained underserved. Ten communities were identified as priority areas, reinforcing policies focused on urban environmental justice. The study recommends replacing uniform expansion plans with strategies that prioritize vulnerable communities, integrating environmental justice into sustainable urban planning.

12	The role of city parks in creating 'wellbeing societies': A case study of Piłsudski Park in Łódź, Poland	2025	To investigate how urban green spaces and parks promote well-being in Polish cities, focusing on Marshal Józef Piłsudski Park in Łódź.	Application of a questionnaire to 238 park users, exploring usage patterns, motivations for visits, selected activities, and perceived benefits for well-being.	Physical activities such as walking were the main motivation for visits, while mental benefits such as relaxation and stress reduction were the most valued. Social interactions had lower overall relevance but were significant for youth, older adults, and marginalized groups (such as the unemployed). Proximity and visit frequency amplified benefits, although passive recreational activities remained predominant. The study advocates inclusive and participatory planning practices, highlighting the potential of parks to address social and health challenges in sustainable cities.
13	Preferring Local over Non-Local Parks? Green Space Visit Patterns by Urban Residents in Desert Cities, Arizona	2025	To investigate whether residents of urban neighborhoods use green spaces closer to their residences more frequently, focusing on Phoenix–Mesa, Arizona (USA).	Analysis of 2019 mobile phone tracking data to identify visitation patterns to local parks, assessing accessibility measures and the social composition of neighborhoods.	Approximately 40% of neighborhoods with available local parks did not prioritize their use. Visit frequency was associated with accessibility and neighborhood social characteristics, with particular emphasis on a nonlinear relationship between the proportion of Hispanic residents and local park use. The study highlights equity implications for urban green space planning.

14	Park Features, Neighborhood Environment, and Time Factors Affect Park Visitor Volume: A Meta-Analysis	2025	To identify, through a meta-analysis, the factors that influence visitor volume in urban parks, considering park attributes, neighborhood characteristics, and temporal aspects.	Meta-analysis of 30 studies, using a statistical technique that quantitatively combines results from multiple independent studies. Random-effects models were applied to estimate average associations between variables such as park size, facilities, population density, and temporal factors.	Park use was higher in areas with large, well-equipped, and well-maintained parks, as well as in neighborhoods with attractions as points of interest. Socioeconomically disadvantaged areas showed lower use, and factors such as water features, vegetation, and transportation exhibited mixed effects, varying by region.
15	Benefits of Various Urban Green Spaces for Public Health Based on Landscape Elements: A Study of Public Visual Perception	2025	To investigate how different landscape elements in urban green spaces influence public health and to propose optimization strategies for urban planning.	Five types of green spaces in Kunming were analyzed (forests, wetlands, urban parks, street green spaces, and residential areas) using semantic segmentation based on PSPNet to quantify landscape elements. Experiments with visual stimuli and analyses of physiological metrics and psychological questionnaires were conducted to assess effects on participants.	Urban forests and parks rich in natural elements (plants, soil, and mountains) had greater impacts on physiological and psychological restoration. Artificially designed spaces could produce similar benefits when they effectively mimicked natural elements. Specific elements—such as plants, soil, and mountains—were more determinant than aggregated indices. Excessive exposure to water negatively affected heart rate stabilization, whereas a higher presence of natural elements favored attention and well-being.

16	Assessing Urban Park Equity in China Through Supply and Demand Balance: A Case Study of Wuhan City, China	2025	To investigate equity in access to urban parks in Wuhan, China, considering park quality and the heterogeneity of demand among different population groups, with particular emphasis on older adults.	Development of a comprehensive evaluation index system incorporating park quality and differentiated demand patterns. Big data from multiple sources and spatial analysis were used to examine the supply and demand of park services and to identify the causes of mismatches.	Central areas were found to have better park quality and supply, while peripheral regions experienced greater deficits, even though demand remained more stable. Older adults were identified as a vulnerable group, with 28.25% of communities lacking adequate service provision. The study recommends expanding the capacity of central parks and prioritizing the creation of new parks in underserved suburban areas to reduce inequalities.
17	How to lead the optimization of parks spatial patterns more comprehensively with the philosophy of green equity: A case of Chengdu	2025	To analyze green equity in the distribution of urban parks in Chengdu, aligned with the United Nations Sustainable Development Goals, and to propose spatial optimization strategies.	Introduction of the Green Equity Index based on the Theil index to measure inequalities, combined with a Support Vector Regression (SVR) model to identify spatial patterns and guide planning solutions.	Accessibility to parks has improved in recent years; however, inequalities in the distribution of green spaces persist. The proposed optimization solution showed potential to efficiently allocate available resources and reduce inequalities, offering practical guidance for sustainable urban planning.
18	Mapping the emotional landscapes of parks in post-industrial communities enduring environmental injustices: Potential implications for biophilic city planning	2025	To analyze the emotional landscapes of urban parks in post-industrial communities marked by environmental injustices, using Camden (New Jersey, USA) as a case study.	Questionnaires were administered to park users and combined with GIS data and a mixed-methods approach to map sentiment patterns and assess perceptions of park attributes.	The study showed that the legacy of environmental injustice influences emotional experiences in parks, that impacts vary across cases and are not uniformly positive, and that larger parks closer to water bodies receive greater investment and more positive evaluations. In addition, users' locations influenced their emotional responses more strongly than factors such as race, ethnicity, or income.

19	Understanding residents' motivation, psychological involvement, and psychological well-being in urban parks	2025	To investigate how motivations for using urban parks influence psychological involvement and the well-being of residents in Dongguan, China..	Questionnaires were administered to 331 residents, and the data were analyzed using Structural Equation Modeling (SEM) and Principal Component Analysis (PCA) to identify factors and test relationships among motivation, involvement, and well-being.	Motivations positively affected psychological involvement and psychological well-being, with involvement acting as a partial mediator. The study recommends expanding leisure resources, accessibility, family-oriented areas, sports, and cultural facilities to strengthen psychological health and community cohesion.
20	Urban Park Planning for Sustainability: Resident Insights from China's Major Cities	2025	To develop a framework to understand and predict residents' spatial perceptions of urban parks, aiming to support sustainable and personalized park management.	Questionnaires were administered to 701 residents in three major urban parks in China (Chaoyang, Century, and Yuexiu). The analysis combined semantic differential (SD)—quantifying subjective perceptions on bipolar scales (e.g., pleasant—unpleasant, safe—unsafe); importance—performance analysis (IPA)—crossing the importance attributed to park elements with perceived performance; and cognitive mapping—to reveal how residents mentally organize park attributes.	Perceptual differences were identified among the three parks, with greater perceived privacy in Chaoyang Park due to stronger natural characteristics, while Century and Yuexiu Parks were better evaluated for aligning design with local needs. Cognitive maps revealed differences in familiarity with natural, social, and artificial landscape functions, reinforcing the importance of integrating design elements adapted to diverse preferences to strengthen sense of place.

21	Assessing Urban Park Accessibility and Equity Using Open-Source Data in Jiujiang, China	2025	To assess accessibility and equity in access to urban parks in Jiujiang, China, considering different dimensions (spatial, opportunity-based, and group-based).	Accessibility was measured using walking route data (via an open API), considering a 1,500 m buffer radius and analyzed through GIS tools to map spatial differences, opportunity-based differences, and disparities among social groups.	Central parks showed better accessibility, but fewer service opportunities within the 1,500 m radius. Strong disparities were identified between neighborhoods, with greater benefits for wealthier communities. The study recommends opening secondary entrances, removing barriers, and creating shared green spaces.
22	How to define urban park relevance? Examining and integrating US National Park Service and partner views on the goal of "relevance to all Americans"	2025	To explore how different perspectives on park "relevance" can be reconciled between the U.S. National Park Service (NPS) and its urban partners, within the context of the Urban Agenda and the goal of "relevance to all Americans."	Sixty-three interviews were conducted with NPS staff and partner organizations in Detroit, Tucson, and Boston. The analysis was based on a Collective Impact framework to examine convergence and divergence in views on park relevance.	Significant differences were identified between the perspectives of NPS staff and their partners, but also opportunities for strategic alignment. The institutional vision of the NPS can serve as a basis for setting shared goals and fostering collaborative planning at the urban scale.
23	How outdoor and indoor green spaces affect human health: a literature review	2025	To review studies on the effects of exposure to green spaces, both outdoor and indoor, on human health and the natural environment.	Literature review conducted in April 2024 using the PubMed, Web of Science, Scopus, Google Scholar, and Google Academic databases. Selected studies assessed the relationship between contact with vegetation and indicators of mental health, physical health, cognitive performance, environmental quality, and social cohesion.	Exposure to vegetation was associated with improvements in mental health (less stress, anxiety, and depression), physical health (blood pressure, heart rate, inflammation), cognition, social recovery, and social cohesion. It also contributed to environmental quality by mitigating heat and noise and strengthening sense of belonging and collective identity.

24	Quantifying physiological health efficiency and benefit threshold of greenspace exposure in typical urban landscapes	2024	To evaluate the physiological effects of exposure to different types of urban landscapes and to identify efficiency and benefit thresholds of greenspace exposure for health.	Social media comment data related to seven parks in Wuhan were analyzed, evaluating dimensions such as facilities, safety, maintenance, environment, and events. The analysis used big data and artificial intelligence techniques to provide real-time assessment.	Blue spaces showed faster efficiency (EEG: 4–5 min; HR: 1 min) but reached the benefit threshold in a shorter time (10 min). Open green spaces showed good initial efficiency (EEG: 5–6 min; HR: 1 min), while enclosed green spaces required more time to reach peak efficiency (EEG: 8–9 min; HR: 6–7 min). Overall, blue spaces were more effective for stress reduction, while open green spaces showed better physiological efficiency.
25	A new framework for assessment of park management in smart cities: a study based on social media data and deep learning	2024	To propose a framework based on machine learning to assess intelligent park management in smart cities, overcoming the limitations of traditional evaluation methods.	Foram analisados dados de comentários de redes sociais referentes a sete parques em Wuhan, avaliando dimensões como instalações, segurança, meio ambiente, atividades e serviços. A análise utilizou big data e inteligência artificial para fornecer uma avaliação em tempo real.	The framework identified management problems and showed that factors such as park type, season, and events (e.g., renovations) influence visitation and satisfaction. Compared with traditional methods, the approach proved more accurate and efficient, providing useful insights for intelligent park management and smart cities.
26	Assessment and optimization of spatial equity for urban parks: A case study in Nanjing, China	2024	To assess accessibility and equity in urban parks in Nanjing, China, integrating distance-based measures, park popularity, and residents' actual choices.	An improved version of the Two-Step Floating Catchment Area (2SFCA) method was applied, integrating real-time usage data to measure park popularity. The Huff model was used to analyze residents' park choices. Equity assessment employed the Gini index, Lorenz curves, and Bivariate Spatial Autocorrelation Analysis.	Central parks in Nanjing showed higher accessibility, while peripheral and disadvantaged communities experienced greater deficits. The study demonstrated pronounced inequities (10% of residents held 36% of accessibility), and only modest improvements were observed when equity was considered alongside park popularity.

27	Does supply match demand? Assessing the relationship between urban parks and residents from the perspective of equity and efficiency	2024	To analyze the relationship between the supply and demand of urban parks in Nanjing, identifying whether existing parks meet residents' needs in an equitable and efficient manner.	Mobile phone signaling data were used to estimate real park use patterns and their spatial overlap with residential areas. The analysis considered four indicators: Urban Park Supply Intensity (UPSI), Park Area Per Capita (PAC), Utilization Rate (UR), and Demand Satisfaction Rate (DSR). To explore factors influencing demand, a Spatial Lag Model (SLM) was applied.	Urban parks cover only about 30% of urban residences, and many areas show low per capita park supply. Most parks were found to efficiently meet local demand, with low demand satisfaction rates (DSR). The study concluded that mismatches between supply and demand are related to uneven spatial distribution, urban planning changes, and differing resident needs.
28	Evaluating the Accessibility of Seniors to Urban Park Green Spaces	2024	To assess accessibility and equity in access to urban green spaces (UPGS) for the elderly population in Ningbo, China, providing input for urban planning.	Urban blocks were used as the unit of analysis, applying the Two-Step Floating Catchment Area (2SFCA) method to measure accessibility based on walking distance. To assess equity, the study employed the Index of Accessibility Difference (IDA), hotspot analysis, and Pearson correlation coefficient.	Accessibility was found to be insufficient, especially in peripheral areas and neighborhoods with a higher concentration of older adults. Public transportation played a key role in improving equity, but spatial distribution remained uneven over time (15, 30, and 45 minutes). The study recommends increasing park supply and adjusting zoning regulations to improve equity and spatial distribution.
29	Spatial equity of urban parks from the perspective of recreational opportunities and recreational environment quality: A case study in Singapore	2024	To assess spatial equity of different categories of urban parks (regional, community, and composite) in Singapore, considering recreational opportunities and environmental quality.	A neighborhood-level evaluation system was developed using Lorenz curves, the Gini coefficient, and local spatial autocorrelation analysis to compare inequalities and distribution patterns.	Inequality in recreational opportunities was greater than inequality in environmental quality. Community parks showed higher inequity compared to regional parks. Both recreational opportunities and environmental quality were unevenly distributed, being concentrated in certain neighborhoods, creating privileged and underserved areas.

30	Towards a sustainable city: Deciphering the determinants of restorative park and spatial patterns	2024	To investigate how observable factors (vegetation, water, visual characteristics) and perceptual factors (landscape preference, place attachment) influence psychological restoration in urban parks and to identify their spatial patterns..	The study was conducted in an urban park in Wuhan, China. A total of 1,560 collaborative images were collected through a public participation geographic information system (PPGIS) and analyzed using deep learning methods to extract landscape visual qualities. Statistical models were applied, including Ordinary Least Squares (OLS), Quantile Regression (QR), and Multiscale Geographically Weighted Regression (MGWR), to assess restorative factors and spatial variations.	Landscape preference, place attachment, and the presence of vegetation and water were strongly associated with psychological restoration. However, restoration intensity varied according to park location and spatial context, revealing spatial heterogeneity. Different areas of the park showed distinct potentials for promoting psychological well-being.
31	The Restorative Effects of Urban Parks on Stress Control Ability and Community Attachment	2024	To investigate how perceived restorative effects of urban parks influence stress reduction and the strengthening of community attachment.	Questionnaires were administered to urban park users to assess perceptions of psychological restoration, stress management ability, and attachment to the community.	Time spent in parks significantly improved stress control capacity and increased place attachment. Participants who reported lower perceived restorative effects showed weaker stress management outcomes. The findings confirm the role of urban parks in mental health promotion and social connection.
32	How does multiscale greenspace exposure affect human health? Evidence from urban parks in the central city of Beijing	2024	To explore how exposure to green spaces at multiple spatial scales (local and subdistrict levels) is associated with residents' physical and self-rated mental health.	Questionnaires were applied to 1,017 residents in Beijing. Objective and subjective measures of greenspace exposure were analyzed using multiple regression models and pathway analyses to examine relationships with health outcomes.	Local-scale greenspace exposure had a stronger impact on mental health, mainly through aesthetic quality and opportunities for rest. Subdistrict-scale park density was more strongly associated with physical health and increased frequency of use. The study confirms that multiscale greenspace effects should be considered in urban planning to promote public health.

33	Study on the Spatial Arrangement of Urban Parkland under the Perspective of Equity—Taking Harbin Main City as an Example	2024	To evaluate spatial and social equity in access to urban parks in Harbin, with a focus on vulnerable populations such as older adults and children.	Points of interest (POI) and areas of interest data were combined with kernel density estimation and GIS-based spatial analysis to map park accessibility. The relationship between supply and demand was measured using the Two-Step Floating Catchment Area (2SFCA) method. Equity was assessed using the Lorenz Curve, Gini Coefficient, Participation Index, and Location Entropy Index.	Urban parks were concentrated in a limited number of areas and served only a portion of the population. The supply–demand relationship was insufficient, with pronounced inequality (Gini = 0.407). Older adults and children in low-income areas faced the lowest levels of access, confirming significant socio-spatial inequity.
34	How do urban parks, neighborhood open spaces, and private gardens relate to individuals' subjective well-being: Results of a structural equation model	2024	To investigate how different types of green infrastructure—urban parks, neighborhood open spaces, and private gardens—are associated with subjective well-being.	An online questionnaire was administered to 322 residents in the Netherlands. Data were analyzed using structural equation modeling (SEM) to assess direct and indirect effects of satisfaction with green spaces on subjective well-being.	Satisfaction with neighborhood greenery had a stronger positive impact on subjective well-being than satisfaction with urban parks. The size of private gardens indirectly influenced well-being by increasing satisfaction with neighborhood green spaces. Satisfaction with neighborhood greenery showed a consistent positive relationship with well-being, regardless of frequency of use.
35	Understanding the sociocultural valuation of ecosystem services in urban parks: a Colombian study case	2024	To investigate the sociocultural values attributed to ecosystem services in five urban parks in Tunja, Colombia.	Semi-structured interviews were conducted with three stakeholder groups (public managers, social leaders, and park users) to identify perceptions and preferences regarding ecosystem services.	Eighteen ecosystem services were identified, with cultural services being the most prominent. Sociocultural values were more strongly influenced by park characteristics than by size, with no significant influence of age, gender, or education. Discrepancies were identified between the perspectives of governmental and non-governmental managers, which may affect policy formulation.

36	An analysis of the effects of different urban park space environment construction on national health	2024	To analyze the multiple health benefits of urban green spaces, including physical and mental health, social interaction, and environmental sustainability, highlighting factors that promote successful implementation and existing challenges.	In-depth case studies were conducted in three parks in China (People's Park in Linyi, Youth Park in Lanshan, and Yumin Park in Yunnan), combined with international reference cases (the High Line in New York and Emscher Landscape Park in Germany) for comparative analysis..	Urban green spaces were shown to be essential for well-being and social cohesion; however, they still face barriers related to land availability and equitable resource distribution. The study highlights the importance of adopting justice-oriented spatial strategies, revising urban policies, and promoting inclusive governance. It also identifies gaps, such as the lack of longitudinal studies and limited understanding of socioeconomic inequalities in park use.
37	A user-based approach for assessing spatial equity of attractiveness and accessibility to alternative urban parks	2024	To propose a user-based method for assessing the attractiveness of urban parks in Tehran, considering inequalities in access and use.	Park attractiveness was modeled based on travel time, available leisure time, and user behavior. Indicators such as Duration of Use Inequality, Visit Frequency, and Choice Opportunity were applied, combined with traffic analysis zones and regional park data.	The method revealed significant inequalities among users, showing that some neighborhoods had substantially higher opportunities for park use than others. In comparison, traditional service-based indices tended to mask these differences and were effective only at a regional scale. The proposed model provides a more detailed understanding of local-scale inequalities in park accessibility and attractiveness.

38	Associations between the perception of ecosystem services and well-being in urban parks	2023	To analyze associations between users' perceptions of cultural ecosystem services and well-being in urban parks in Recife, Brazil.	A total of 481 questionnaires were applied in ten urban parks. Data on park perception, self-perceived health, and willingness to pay were analyzed using Stata 14, with four ordinal logistic regression models.	Users with better mental health and lower stress reported higher perceptions of ecosystem service benefits. Willingness to pay was also associated with positive park perceptions. The study reinforces the role of ecosystem services in promoting well-being and highlights the need to incorporate them into urban park planning.
39	The role of urban parks in affecting health outcomes and the differences between vulnerable groups: Evidence from the central city of Beijing	2023	To understand how urban parks influence public health and environmental justice outcomes in Beijing, with particular attention to older adults and low-income populations.	Different types of green spaces and their spatial distribution across subdistricts were analyzed. Multiple linear regression models were applied to assess the impact of factors such as quantity, density, distance, and park quality on residents' health.	Urban parks had a stronger impact on health than other types of green spaces. For older adults, park density and distance were decisive factors, while for urban residents overall, vegetation quality had a greater influence. The study concludes that accessible and free urban parks should be prioritized in urban planning to improve public health and reduce inequalities.
40	Does the Urban Park Provision Fit the Social Needs of the Community? Evidence for Semarang City, Indonesia	2023	To identify which categories of park services best meet community needs in Semarang, Indonesia.	Semi-structured questionnaires were applied to 100 users in five urban parks. Data were analyzed using a scoring method and compared with hypothetical reference categories.	Urban park services were generally classified as "medium," with strengths in facilities, quality, tree diversity, cleanliness, air quality, ventilation, and social use. However, some services did not fully meet community needs, indicating the necessity of targeted improvements to better adapt parks to local demands..

41	Green spaces for whom? A latent profile analysis of park-rich or -deprived neighborhoods in New York City	2023	To classify neighborhoods in New York City according to socioeconomic characteristics and green space provision, in order to understand patterns of park distribution.	Latent profile analysis was applied to group neighborhoods probabilistically based on combinations of socioeconomic characteristics and green space provision indicators.	Urban parks were not evenly designed or distributed; their presence varied according to the socioeconomic profiles of neighborhoods. The analysis identified differentiated patterns among social and local groups, reinforcing the need for context-sensitive policies to promote green equity and socio-spatial justice.
42	The Importance of Urban Green Spaces in Enhancing Holistic Health and Sustainable Well-Being for People with Disabilities: A Narrative Review	2023	To discuss how urban green spaces can improve health, well-being, and quality of life for people with disabilities, emphasizing inclusion in sustainable urban planning..	Conceptual and narrative review article addressing different levels of disability experience (global, population-level, individual) and different modes of interaction with green spaces (active, passive, direct, and indirect).	People with disabilities receive less attention in access to services and green spaces, despite having high potential to benefit from these environments. The study highlights that sustainable urban policies should prioritize inclusion, expanding environmental, social, and economic benefits and contributing to more equitable and sustainable cities.
43	The optimal spatial delineation method for the service level of urban park green space from the perspective of opportunity equity	2023	To investigate spatial equity in access to urban park green spaces (UPGS) in the district of Yingge, Taiwan, considering both quantity and quality to support fairer urban planning.	A modified micro-scale accessibility approach was applied, using buildings as demand points and service catchments as supply areas. Different service radii were compared, and UPGS quality was incorporated into the assessment.	Significant differences were identified when a uniform service radius was applied, revealing access inequalities. Including quality in the analysis highlighted areas with both high and low service levels. The delimitation method improved public resource allocation and supported better infrastructure planning, ensuring residents had adequate access to parks with satisfactory quality.

44	Policy-maker and Practitioner Perceptions of Parks for Health and Wellbeing: Scoping a Holistic Approach	2023	To investigate how different qualities of urban parks—such as size, types of facilities, accessibility, community engagement, and green–blue infrastructure— influence health and well-being outcomes in cities, within the broader <i>Better Parks, Healthier for All</i> project.	An online focus group was conducted in May 2021, during the COVID-19 context, with 19 specialists from New South Wales, Australia, including park providers, policymakers, designers of green spaces, and public health researchers. Data were analyzed using thematic analysis.	The analysis revealed a holistic view of park quality, in which each space plays a complementary role within an integrated network of benefits. Co-design and community engagement were highlighted as essential to strengthen a sense of belonging and park use. The study concludes that well-connected and well-planned parks are fundamental infrastructures for health, well-being, and environmental sustainability.
45	Assessment of spatial equity of urban park distribution from the perspective of supply-demand interactions	2023	To assess equity in the spatial distribution of urban parks by overcoming traditional approaches that focus only on supply, incorporating residents' demand, usage preferences, and scale effects.	A composite index called Supply–Demand Equity Index (SDEI) was developed, combining accessibility to parks most frequently used and closest to residents (supply) with residents' perceptions obtained through surveys and population density. Data were analyzed at the neighborhood scale to capture supply–demand interactions more precisely.	Results showed that accessibility-based indicators better represented service provision than proximity alone, while demand-based approaches captured residents' perceptions but revealed hidden inequalities. The SDEI identified spatial mismatches between supply and demand, revealing inequitable patterns. The study concludes that combining indicators produces more robust assessments and has direct implications for urban park planning.
46	The Productive Role of Future Expectations in Participatory Spatial Planning. A Case Study on Urban Park Development in The Netherlands	2023	To examine the role of future expectations in spatial planning, a dimension still underexplored in the literature, using participatory planning processes in the development of Seelig Park, in Breda, the Netherlands.	A grounded theory approach was applied to analyze the participatory planning process, focusing on how expectations emerge, evolve, and influence decisions over time.	Expectations were found to be flexible, dynamic, and diverse, functioning as mechanisms of “recalibration” that shape the ongoing planning process. The study concludes that productive expectations help balance legitimacy and equity within the politically negotiated context of spatial planning.

47 Assessment and planning of green spaces in urban parks: A review	2023	To analyze how investments in green areas and sustainable development policies can enhance urban parks and contribute to population well-being, emphasizing the importance of spatial planning in large cities.	This is a review article that employed Geographic Information System (GIS) techniques to assess accessibility, guide spatial changes, and identify relationships between the proportion of green areas and the creation of green corridors.	The study showed that high proportions of green coverage favor the establishment of green corridors, which are essential for urban balance. The proposed methodology allows the adaptation of vegetation to lot design, supports urban requalification plans, reduces flood risks, and promotes biodiversity and heritage preservation through durable green spaces.
48 Impact of Urban Historical Parks on Physical Activity and Public Health in Beijing	2022	To explore the influence of urban historical parks on residents' physical activity and public health, based on a study of three emblematic parks in Beijing—Beihai Park, the Forbidden City, and the Temple of Heaven—and to propose recommendations for their management and revitalization.	Levels of residents' physical activity, park characteristics, and general public health were investigated. Statistical correlation methods were applied to analyze relationships between environmental, social, and health-related variables.	Physical activity in historical parks was associated with tranquility, attractiveness of the landscape, and available space. Physical activity correlated with companionship, while mental health was related to education level, frequency of visits, and scenic qualities. These parks play a central role in cultural preservation and social cohesion, in addition to providing health benefits.

49	Park equity: Why subjective measures matter	2022	To investigate how subjective perceptions of park quality and availability vary according to race/ethnicity, income, and metropolitan region in the United States, advancing beyond studies focused solely on objective access measures such as proximity.	Data from a survey conducted in six metropolitan areas were analyzed using mixed linear models to test interactions between race/ethnicity and region. Both subjective perceptions and objective metrics—such as ParkScore , which evaluates park access and quality—were considered.	Perceptions of park quality and availability varied across regions, being more critical in Baltimore and Los Angeles, less negative in Boston, and more positive in Phoenix and Minneapolis–St. Paul. Black and Hispanic residents reported more park-related problems, although Hispanic respondents also perceived improvements more frequently. Overall, income was not a determining factor, and subjective perceptions generally aligned with ParkScore objective metrics.
50	Assessing the social equity of urban parks: An improved index integrating multiple quality dimensions and service accessibility	2022	To propose an improved assessment of environmental equity in urban parks by integrating both accessibility and multidimensional quality, with a focus on socially vulnerable groups such as older adults, children, and unemployed populations.	An index was developed combining quality dimensions—including aesthetic features (AFs), facilities and recreational functions (FCS)—with accessibility measures, resulting in a total composite score (TS). The index was applied to urban parks in Xangai, considering different socioeconomic groups.	Convenience facilities were the most accessible services, followed by aesthetic and recreational aspects. Older adults and unemployed populations had greater access to higher-quality parks, while children experienced lower access. The proposed index proved effective for guiding planning and management, highlighting the importance of balancing supply and demand and improving park quality to enhance social equity.

51	Sustainable low-input urban park design based on some decision-making methods	2022	To develop methodologies that incorporate Life Cycle Costing (LCC) and rational resource use in order to optimize the design and maintenance of urban parks, making them more sustainable and cost-effective.	The study was conducted in Mashhad, Iran, comparing two park design scenarios: a conventional design based on general project standards and a low-investment design emphasizing sustainability. Methods from Value Engineering (VE), Multicriteria Decision Making (MCDM), and Risk Management (RM) were integrated to select indicators and analyze costs.	The low-investment plan reduced total costs by 62.7% compared to the conventional design, mainly due to reduced resource consumption and lower long-term maintenance costs, despite slightly higher initial expenses. The study concludes that VE is an effective tool for balancing costs, improving project quality, and supporting sustainable urban park management.
52	How urban parks nurture eudaimonic and hedonic wellbeing: An explorative large scale qualitative study in Québec, Canada	2022	To investigate urban park users' perceptions regarding their motivations for using these spaces, their impacts on well-being, and the park qualities that underpin these benefits.	Interviews were conducted with 449 adults across 20 urban parks in four cities in Québec, Canada. Thematic analysis was applied to identify patterns in users' motivations and perceived effects.	Three overarching themes explained park use: caring for oneself, caring for children, and caring for others. Users sought both hedonic well-being , related to leisure and pleasure, and eudaimonic well-being , associated with connection to oneself and to others. The study concludes that urban parks play a fundamental role in health promotion and should be prioritized in urban planning.
53	The role of the state in preserving urban green infrastructure - National Urban Parks in Finland and Sweden	2022	To analyze how different implementation models of National Urban Parks (NUPs) influence their effectiveness as instruments for preserving green infrastructure in cities.	A comparative analysis was conducted between two implementation approaches: a top-down model imposed by the state, as observed in Sweden, and a bottom-up model initiated by municipalities and civil society, as in Finland. The study examined the role of the state and local governments in the creation and management of NUPs.	In Sweden, the top-down model resulted in resistance from municipalities, limiting future development. In Finland, the bottom-up model led to broader acceptance of NUPs, as municipalities competed for their designation. The study concludes that although NUPs are effective tools for protecting green areas, their success depends strongly on the implementation model.

54	Associations between greenspace and mental health prescription rates in urban areas	2021	To expand understanding of the relationship between the availability of urban green spaces and mental health, analyzing how these spaces impact prescription rates for mental health disorders at a national scale in Scotland.	Linear mixed-effects models were applied to all Scottish settlements with more than 10,000 inhabitants. Greenspace availability was measured at two spatial scales—immediate neighborhood and up to a 30-minute walking distance—while controlling for sociodemographic variables, spatial autocorrelation, and health board effects.	In areas with a higher proportion of ethnic minorities and families experiencing multiple deprivation, greater availability of nearby green spaces was associated with lower prescription rates for mental health disorders. No significant association was found for green spaces within a 30-minute walking distance. The findings indicate that the mental health benefits of green spaces vary according to population profiles, providing important insights for urban planning and national-level policy.
55	Do persons with low socioeconomic status have less access to greenspace? Application of accessibility index to urban parks in Seoul, South Korea	2021	To examine socioeconomic inequalities in access to urban parks in Seoul, South Korea, framing park accessibility as an environmental justice issue.	Two parks provision metrics were analyzed: total park area per capita (TPPC) and an accessibility index that considers park size and proximity. Correlation and regression analyses were conducted at multiple administrative levels— 25 districts and 424 neighborhoods —relating these metrics to socioeconomic variables.	The accessibility index proved more sensitive to inequalities than TPPC. Areas with a higher proportion of elderly residents and low-income populations showed greater access to parks, while areas with higher divorce rates exhibited lower accessibility. The findings indicate that detailed measures incorporating proximity and park size better capture environmental inequalities than simple metrics, providing relevant guidance for urban planning.

56 Assessing the performance of urban open space for achieving sustainable and resilient cities: A pilot study of two urban parks in Dublin, Ireland	2021	To evaluate how urban open spaces contribute to urban resilience and sustainability in the context of climate change and urbanization, proposing a method to assess their socioecological performance.	A methodology was developed using 26 measurable indicators related to ecosystem services and spatial configuration. The index was applied to two urban parks in Dublin, Ireland, as a pilot study to test its usefulness.	The index proved effective in assessing the contribution of urban parks to urban resilience, enabling the identification of strengths and weaknesses in park design. The proposed method serves as a practical tool for urban planners and managers, supporting both the evaluation of existing open spaces and the planning of new ones, reinforcing the integration of urban design and sustainability.
57 The neighborhood socioeconomic inequalities in urban parks in a High-density City: An environmental justice perspective	2021	To investigate how the quantity and quality of urban parks are related to socioeconomic deprivation and the presence of ethnic minorities at the neighborhood level, using Hong Kong as an example of a high-density city.	A total of 102 urban parks distributed across 209 Tertiary Planning Units (TPUs) were evaluated. Park quantity and quality were measured objectively between April and June 2018 using Geographic Information Systems (GIS) and a Community Park Audit Tool.	No direct association was found between the quantity of parks and amenities, safety, or aesthetics with socioeconomic deprivation or ethnic minorities. However, areas with greater socioeconomic deprivation showed higher park quantity but lower diversity of facilities. Neighborhoods with a higher presence of ethnic minorities had parks with fewer facilities and lower diversity, revealing distributive inequalities.

58	The planning and design of good quality urban parks in China: the perspectives of technical professionals	2021	To investigate the factors influencing the quality of urban parks during the planning, design, and investment phases, considering political, technical, and governance barriers.	Interviews were conducted with technical professionals working as consultants for local governments in urban planning and landscape projects across different regions of China.	The study identified three main factors influencing park quality: reliance on quantitative metrics in contemporary planning; the relationship between political will, leader prestige, and administrative engagement; and the importance of technical expertise and effective communication between managers and professionals. These elements directly shape the planning and design of high-quality urban parks.
59	Promoting goal-driven performance evaluation: a case study of an urban park in Florida, USA	2021	To highlight the importance of goal-oriented performance evaluation in landscape projects, demonstrating its application through a case study of an urban park in Florida, USA.	Depot Park was analyzed by assessing its level of achievement in relation to four project objectives defined at the outset. The research included a review of the planning process and an analysis of the results achieved.	The study showed that it is possible to verify whether a project is progressing toward its objectives; however, measuring the level of achievement remains challenging. The findings emphasize the need to establish clear goals, benchmarks, and comparative performance measures to improve future evaluations of landscape projects.
60	Urban green spaces for the social interaction, health and well-being of older people— An integrated view of urban ecosystem services and socio-environmental justice	2020	To analyze how older adults use urban green spaces in Berlin (Germany) and which social and health factors influence this use, relating the findings to dimensions of socio-environmental justice.	Comprehensive data were used on park visitation patterns, demographic characteristics, and social networks of older adults, allowing the identification of associations between social context, health, and frequency of park use.	Older adults with strong social ties (children, friends, close neighbors) visit parks more frequently, while socially isolated individuals use green spaces less. In addition, a positive perception of health increases visitation frequency. The study proposes integrating ecosystem services, social ties, and socio-environmental equity into urban planning.

61	Social and Structural Determinants of Self-Rated Health in Gentrifying Neighborhoods in Austin, Texas: A Cross-Sectional Quantitative Analysis	2022	To analyze how social and structural factors influence self-rated health in neighborhoods of Austin undergoing gentrification.	A cross-sectional quantitative study was conducted using multivariate statistical analysis based on population and neighborhood-level data.	C Housing conditions, racial composition, socioeconomic status, and gentrification directly affect perceived health, revealing social inequalities. The study recommends urban planning policies that integrate social justice and health equity.
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SWOT ANALYSIS OF ESG PRACTICES AMONG RURAL SUGARCANE PRODUCERS IN THE STATE OF SÃO PAULO

ANÁLISE SWOT DE PRÁTICAS ESG ENTRE PRODUTORES RURAIS DE CANA-DE-AÇÚCAR NO ESTADO DE SÃO PAULO

ANÁLISIS FODA DE LAS PRÁCTICAS ESG ENTRE LOS AGRICULTORES DE CAÑA DE AZÚCAR EN EL ESTADO DE SÃO PAULO



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ABSTRACT

This article aimed to analyze Environmental, Social, and Corporate Governance (ESG) practices among sugarcane producers in the state of São Paulo, seeking to identify their potential impacts and challenges. Specifically, the SWOT methodology was applied to assess the relevance of ESG adoption, as well as to characterize the organizational environment, considering variables from both the general and task environment, in order to understand internal and external factors that influence its implementation. The research was based on bibliographic and documentary review, with emphasis on sustainability reports from companies in the sugar-energy sector, integrating discussions on agribusiness and corporate governance. The results indicated that, in the environmental dimension, strengths such as circular economy and the use of clean technologies prevail, while weaknesses remain related to the use of fossil fuels and waste management. In the social dimension, progress was observed in inclusion and community projects, although gaps persist in equity and the participation of small producers. In the governance dimension, certifications and compliance structures stand out, contrasting with limitations in cybersecurity and the difficulties of independent producers to adhere. It is concluded that the effective incorporation of ESG strengthens the sustainability and competitiveness of the sector, provided it is accompanied by innovation, capacity building, and integrated management strategies. It should be noted as a limitation the dependence on secondary sources, especially reports from mills, which may reduce the representativeness of small and medium-sized producers.

Keywords: Sustainability. Corporate Governance. Competitiveness. Agribusiness. Circular Economy.

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RESUMO

Este artigo teve como objetivo analisar as práticas de Governança Ambiental, Social e Corporativa (ESG) entre produtores rurais de cana-de-açúcar no estado de São Paulo, buscando identificar seus potenciais impactos e desafios. Especificamente, pretendeu-se aplicar a metodologia SWOT para avaliar a relevância da adoção do ESG, bem como caracterizar o ambiente organizacional, considerando variáveis do ambiente geral e de tarefa, a fim de compreender fatores internos e externos que influenciam sua implementação. A pesquisa fundamentou-se em revisão bibliográfica e documental, com ênfase em relatórios de sustentabilidade de usinas do setor sucroenergético, integrando discussões sobre agronegócio e governança corporativa. Os resultados indicaram que, no eixo ambiental, predominam forças como a economia circular e o uso de tecnologias limpas, enquanto persistem fragilidades ligadas ao uso de combustíveis fósseis e à gestão de resíduos. No eixo social, evidenciam-se avanços em inclusão e projetos comunitários, embora haja lacunas em equidade e na participação de pequenos produtores. Já no eixo governança, destacam-se certificações e estruturas de compliance, contrastando com limitações em cibersegurança e dificuldades de adesão de produtores independentes. Conclui-se que a incorporação efetiva do ESG fortalece a sustentabilidade e a competitividade do setor, desde que acompanhada de inovação, capacitação e estratégias integradas de gestão. Cabe destacar como limitação a dependência de fontes secundárias, especialmente relatórios de usinas, o que pode reduzir a representatividade de pequenos e médios produtores.

Palavras-chave: Sustentabilidade. Governança Corporativa. Competitividade. Agronegócio. Economia Circular.

RESUMEN

Este artículo tuvo como objetivo analizar las prácticas ambientales, sociales y de gobernanza corporativa (ASG) entre los productores de caña de azúcar en el estado de São Paulo, buscando identificar sus potenciales impactos y desafíos. Específicamente, se buscó aplicar la metodología FODA para evaluar la relevancia de la adopción de ASG, así como caracterizar el entorno organizacional, considerando variables del entorno general y de la tarea, con el fin de comprender los factores internos y externos que influyen en su implementación. La investigación se basó en una revisión bibliográfica y documental, con énfasis en informes de sostenibilidad de ingenios del sector azucarero-energético, integrando discusiones sobre agronegocios y gobernanza corporativa. Los resultados indicaron que, en el eje ambiental, predominan fortalezas como la economía circular y el uso de tecnologías limpias, mientras que persisten debilidades relacionadas con el uso de combustibles fósiles y la gestión de residuos. En el eje social, se evidencian avances en inclusión y proyectos comunitarios, aunque existen brechas en equidad y en la participación de pequeños productores. En el ámbito de la gobernanza, destacan las certificaciones y las estructuras de cumplimiento, en contraste con las limitaciones en ciberseguridad y las dificultades en la adopción de los principios ESG (Ambientales, Sociales y de Gobernanza) por parte de los productores independientes. Se concluye que la incorporación efectiva de los criterios ESG fortalece la sostenibilidad y la competitividad del sector, siempre que se acompañe de innovación, capacitación y estrategias de gestión integradas. Una limitación a destacar es la dependencia de fuentes secundarias, especialmente informes de ingenios azucareros, lo que puede reducir la representación de los pequeños y medianos productores.

Palabras clave: Sostenibilidad. Gobierno Corporativo. Competitividad. Agroindustria. Economía Circular.

1 INTRODUCTION

Sustainable practices play an important role in all organizational sectors, including agriculture. From 2004 onwards, such practices began to receive greater attention on the international scene, driven by the "*Who Cares Wins*" report, the result of an initiative of the United Nations (UN) in partnership with the financial market. This discussion focused on investment security, highlighting the need for organizations and products to incorporate environmental, social, and governance criteria into their operations, in order to promote positive impacts and foster more sustainable investments (Global Compact, 2025).

In this context, the concept of ESG (Environmental, Social and Governance), although still often interpreted as a market trend, establishes a direct relationship with the Sustainable Development Goals (SDGs), configuring itself as a strategic instrument for the incorporation of sustainability into corporate and sectoral practices (Global Compact, 2025). The adoption of sustainable practices is intrinsically linked to well-structured governance models that are appropriate to the reality in which the organization operates, enabling greater integration between stakeholders and favoring expanded attention to the environmental and social dimensions (Caetano, 2023).

The implementation of ESG in the rural context requires a comprehensive assessment of existing processes, interactions with *stakeholders*, and the potential positive or negative impacts resulting from this adoption. The integration of ESG principles can occur in different dimensions of agricultural property: in the environmental pillar, through the management and conservation of water and soil resources; in the social pillar, through the guarantee of human and labor rights; and in the governance pillar, with a focus on risk management and alignment among stakeholders (Brazilian Institute of Sustainability, 2021). In the case of sugarcane, a prominent crop in Brazil and particularly in the state of São Paulo, its development is favored by factors such as logistical infrastructure, proximity to educational and research institutions, and the presence of cooperatives and associations that bring together a large number of producers (Government of the State of São Paulo, 2023b).

Thus, the objective of this research was to analyze the practices of Environmental, Social and Corporate Governance (ESG) for rural producers in the context of the State of São Paulo, in order to identify their potential environmental and social impacts.

Specific Objectives:

- a. Conduct an analysis using the SWOT Methodology to assess the relevance and challenges of ESG for rural producers.

- b. To characterize the organizational environment of rural sugarcane producers in the state of São Paulo, in order to understand the factors that influence the adoption of ESG practices

2 LITERATURE REVIEW

The implementation of ESG practices in agribusiness has gained increasing relevance, especially in a sector where several areas interact and the balance between them is essential to avoid excessive exploitation in search of economic results. The issue of deforestation for the opening of new agricultural areas, in contrast to the exponential increase in demand for food production in Brazil, exemplifies the challenges faced by agribusiness. Such situations have intensified the pressure on the sector to adapt to ESG parameters, seeking to harmonize environmental sustainability with production needs (Senar, 2023).

According to data from the Department of Agriculture and Supply, the state of São Paulo has approximately 350 thousand rural producers working in various niches. This contingent plays a significant role in the Brazilian context, standing out not only for the extension of the harvested area in hectares and the high average yield, but also for its relevance in exports, crop diversification, job creation, and contribution to the state's Gross Domestic Product (GDP). These factors highlight the importance of the rural sector compared to large urban centers, not only in food production, but also in its indirect impacts on the economy and society (Government of the State of São Paulo, 2023a).

Sugarcane production can be greatly benefited by the adoption of sustainable practices based on ESG principles. Measures such as reducing greenhouse gas (GHG) emissions, private social investment, and improving working conditions in rural areas and in companies contribute to obtaining and regulating sustainable certifications and titles. These actions not only generate positive impacts on the environment and society, but also promote financial returns, strengthening the competitiveness and reputation of the sector (Melo, 2025).

3 METHODOLOGY

3.1 DATABASE

The study will be developed through a literature review, including academic papers, institutional publications and sustainability reports, including ABNT PR 2030, a recommendation of the Brazilian Association of Technical Standards for the implementation of ESG (*Environmental, Social and Governance*) in Brazil. The qualitative analysis will follow an explanatory approach (Gil, 2008), seeking to identify factors that

influence the adoption of sustainable practices in rural areas. According to Manzo (1971), this methodology allows exploring and deepening areas of knowledge that have not yet been consolidated. Based on the characterization of the standards, the SWOT methodology will be applied to assess strengths, opportunities, weaknesses and threats of the rural sector in the Brazilian context.

3.2 SWOT ANALYSIS

SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis, or FOFA, is a widely used methodology to assess an organization's internal and external environments, allowing the identification of competitive advantages, weaknesses, growth opportunities, and risks (Hofrichter, 2021; Fischmann, 1991). An example is the study by the Muza Brasil Cooperative, focused on the commercialization of handicrafts from banana by-products, which presented strengths such as government support and export incentives, and weaknesses such as income limitations and high technological costs (Appio et al., 2009).

The strengths correspond to internal factors that confer competitive advantages, such as resources, product quality and organizational skills. In the study by Amorim (2015) on the dairy industry in Pará, the low barrier to entry of new companies and government incentives stand out, even in the face of consolidated competition.

Opportunities are external factors that favor growth, such as access to resources or favorable market conditions. Galvão (2008), when diagnosing tourism in Itabaiana (PB), identified opportunities such as strategic location, logistics infrastructure and cultural appreciation.

Weaknesses refer to internal limitations that compromise competitiveness, such as high costs and low qualification of the workforce. Dourado (2020) identified, in beef cattle farming, weaknesses such as lack of standardization, low sensory quality, and absence of regulation due to deficiency in inspection.

Threats are external factors that pose risks, such as regulatory, economic, or climate changes. Gonçalves (2024) pointed out, in a private environmental reserve, threats such as climate change, user negligence, and industrial pollution, which compromise sustainability and alignment with the SDGs.

3.3 GENERAL ENVIRONMENT AND TASK ENVIRONMENT

The general environment comprises the entire ecosystem in which the organization is inserted, including agents, conditions and variables that directly or indirectly influence its

operations (Chiavenato, 2007). Given the complexity and dynamics of the market, it is essential to map these variables in order to develop an efficient strategic plan, capable of adapting the organization to changes and supporting decision-making (Matos, 2007). Among these variables, the technological ones stand out, which refer to the constant advancement of innovations, whether developed internally or acquired externally, playing a fundamental role in the optimization of processes and operations.

Legal variables are also relevant, as they involve laws and regulations that structure society, and can be presented as impositions or incentives, while establishing limits and obligations for organizations. Political variables, on the other hand, encompass the political context that influences operations, strategies, and workforce, including public policies and specific regulations. Economic variables, in turn, directly affect business performance, reflecting on profitability, purchasing power, investment capacity, and the dynamics of supply and demand. In addition, demographic factors, such as culture, religion, gender, and age group, shape market and communication strategies, while ecological variables are related to physical and natural aspects that impact the sustainability of operations and socio-environmental responsibility. Finally, cultural variables, which encompass values, beliefs, and practices, influence the behavior of stakeholders and the way the organization relates to its stakeholders (Matos, 2007).

The task environment refers to the context directly linked to the organization, composed of variables that impact goals, objectives and results, significantly influencing the strategic and operational direction. In this environment, the suppliers of inputs stand out, responsible for guaranteeing raw materials and resources indispensable for the functioning of organizational activities, as well as customers or users, who represent the final consumers of the products or services and whose satisfaction is decisive for the success of the organization (Daft, 2003).

Another essential factor is the competitors, which are part of the same sector and compete for consumer preference, in addition to influencing the dynamics of the market and the company's position in relation to other actors. Regulatory entities are also included, responsible for supervising and standardizing activities, ensuring compliance with applicable laws, policies and regulations. These elements, together, make up a scenario that requires constant attention and strategic adaptation on the part of organizations (Daft, 2003).

4 RESULTS AND DISCUSSIONS

The SWOT methodology was applied to the three axes of ESG — Environmental, Social and Governance — to assess the relevance, potentialities and challenges of the implementation

of ESG principles by rural producers in the sugar-energy sector, based on sustainability reports from sugarcane producers in different regions of São Paulo. In addition, the organizational environment was analyzed, segmented into general and task (Daft, 2003). In the general environment, technological, legal, political, economic, demographic, ecological and cultural variables are examined, which largely influence the organization's ecosystem. In the task environment, suppliers, customers, competitors and regulatory entities are evaluated, considering factors that directly impact the organizational functioning.

5 ENVIRONMENTAL

Tables 1 and 2 present the application of the SWOT methodology to the environmental axis, with the objective of analyzing the internal (strengths and weaknesses) and external (opportunities and threats) aspects related to rural producers in the sugar-energy sector.

5.1 INTERNAL FACTORS: STRENGTHS AND WEAKNESSES

The analysis of the environmental axis shows advances in the adoption of sustainable practices by rural producers in the sugarcane sector in São Paulo. Strategies such as the use of pre-sprouted seedlings (MPB), raw sugarcane harvesting, green manures and biological pest control contribute to soil conservation and the reduction of greenhouse gas (GHG) emissions.

The diversification of energy sources, with biofuels, solar energy, and biomass, provides greater energy autonomy and reduces the carbon footprint. The reuse of water in industrial processes also reinforces environmental commitment. Environmental recovery projects, including restoration of Permanent Preservation Areas (PPAs), reforestation, and production of native seedlings, demonstrate efforts to preserve local fauna and flora, complemented by conservation partnerships.

The use of sugarcane by-products, such as vinasse, filter cake, soot and biomass, strengthens the circular economy, allowing the production of organic fertilizers, cogeneration of clean energy and reduction of inadequate waste disposal.

Among the weaknesses, the predominant use of fossil fuel-powered machinery and the limitation in the reuse of some by-products, such as soot, stand out, indicating the need for research and innovation. Other weaknesses include treatment of contaminated areas, control of hazardous products, and mitigation of noise pollution, which require greater standardization and monitoring.

In summary, the sector has made significant advances in sustainable practices, but still requires the integration of clean technologies, expansion of waste reuse, and consolidated

environmental remediation strategies to strengthen a sustainable production model aligned with current standards.

Table 1

SWOT of the internal factors of the Environmental axis

	Positive Factors	Negative Factors
	Strengths	Weaknesses
	Adoption of no-burn harvesting, MPB, green manures, and precision agriculture (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Use of biomass, ethanol, and solar energy for energy self-sufficiency (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Water reuse and closed effluent treatment systems and little dependence on water resources (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Recovery of APPs and reforestation (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Circular Economy of Sugarcane with good use (filter cake, vinasse, biomass) (Cocal, 2024; Delta Sucroenergia, 2024; São Martinho, 2024; Lins Plant, 2023; São Manoel Plant, 2023). Regulations and best practice standards to support ESG compliance.	Partial dependence on fossil fuels in mechanized operations (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Lack of clear remediation planning for contaminated area situations. Low approach to dangerous products and noise pollution, with occasional exceptions. Circular economy concentrated in vinasse, filter cake and bagasse; little use of other waste.

Source: Prepared by the author.

5.2 EXTERNAL FACTORS: OPPORTUNITIES AND THREATS

The expansion of ESG practices among sugarcane producers in São Paulo is an essential strategy to consolidate competitive advantage, with emphasis on international certifications such as Bonsucro and GRI, which increase credibility, visibility, and access to new markets. Technological innovation emerges as a strategic element, promoting partnerships with

startups, participation in open innovation programs, and collaboration with universities, through initiatives such as Hackathons, in addition to fostering the reuse of industrial waste and the circular economy.

The expansion of the circular economy still presents significant opportunities. Although the reuse of vinasse, filter cake, and biomass is consolidated, other waste, such as recyclable materials and organic waste, can still be used, generating new sources of revenue and reducing environmental impacts. The sale of surplus renewable energy also represents an opportunity, strengthening energy self-sufficiency and encouraging the use of clean matrices in adjacent regions.

On the other hand, the sector faces environmental and regulatory threats. Extreme weather events, intensified by climate change, can compromise biomass production and supply. In addition, the growing demand for transparency exposes potential environmental failures, requiring strict monitoring and agile corrective actions. Non-compliance with environmental legislation can also generate sanctions, financial impacts, and damage to institutional reputation, affecting business continuity.

In summary, the environmental axis shows advances in the adoption of sustainable practices and expansion of the circular economy, but reinforces the need for integrated risk management strategies, technological innovation, and adoption of ESG certifications to strengthen the resilience of the sector and consolidate a sustainable production model.

Table 2

SWOT of external factors of the Environmental axis

	Positive Factors	Negative Factors
	Opportunities	Threats
	Expansion of the reuse of various waste (oil, soot, packaging) (São Manoel, 2023). Certifications such as Bonsucro and GRI as a competitive advantage (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Partnerships with startups, open innovation programs, and educational programs (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Lins Plant, 2023; São Manoel Plant, 2023).	Climate change and severe droughts. Pressure for traceability and transparency can expose environmental failures. Risk of environmental sanctions for non-compliance with environmental legislation

	Sale of surplus renewable energy and incentives for the use of renewable energy (solar energy) (Cocal, 2024; Ester, 2022).	
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Source: Prepared by the author.

6 SOCIAL

In Tables 3 and 4, the SWOT methodology was applied to the Social axis, in order to analyze internal characteristics (strengths and weaknesses) and external characteristics (opportunities and threats) related to rural producers in the sugar-energy sector.

6.1 INTERNAL FACTORS: STRENGTHS AND WEAKNESSES

The analysis of the social axis in the sugarcane sector in São Paulo shows significant advances in the well-being and development of employees. The formalization of labor relations, consolidated by the CLT, represents an important milestone, although complete adherence to legislation and the creation of environments that promote both worker and organizational growth still present challenges.

Companies with positive results in social sustainability invest in occupational health and safety, including health plans, first aid training, accident prevention, and firefighting, promoting autonomy and a safe and collaborative environment.

The social axis also covers the appreciation of the local community, through social projects such as support for NGOs, professional training, community gardens, and incentives for social organizations. The inclusion of minority groups, such as women, people with disabilities, and the LGBTQIA+ population, contributes to a more equitable corporate environment. Cooperatives and rural associations, such as COPLACANA, play a strategic role by combining economic activities and social actions, showing that structured practices can be adopted by producers of different sizes.

Among the weaknesses identified are gaps in freedom of association and equitable remuneration, as well as in communication with consumers and suppliers. In addition, many independent producers face financial and structural limitations in implementing robust social practices, restricting the reach and impact of actions.

In summary, the sector presents strategies that promote well-being and community development, but still demands greater social inclusion, wage equity, transparency in relation to union freedom and integration of independent producers, strengthening the positive social impact and image of the sector.

Table 3*SWOT of the internal factors of the Social axis*

	Positive Factors	Negative Factors
	Strengths	Weaknesses
	Territorial development programs, ensuring education, health, and safety (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Inclusion of PWDs, women, LGBTQIA+ population and campaigns to value diversity (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Lins Plant, 2023; São Manoel Plant, 2023). Strengthening of cooperatives and associativism. Codes of conduct in conjunction with the consolidation of Labor Laws (CLT) for rural workers (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023).	Few clear data on freedom of association and equitable remuneration. Little exploration of customer relationships (reports more focused on suppliers) Less engagement of independent producers in structured social practices.

Source: Prepared by the author.

6.2 EXTERNAL FACTORS: OPPORTUNITIES AND THREATS

The adaptation of organizations to sustainability practices in the social axis has stood out as a competitive differential, especially in retaining and attracting talent. Among the opportunities are social actions aligned with the Sustainable Development Goals (SDGs), which favor organizational and social development.

Sugarcane producing companies, for example, invest in education and training, offering financial support, training, and digital inclusion, literacy, and accessibility projects, promoting the improvement of employees' working and living conditions. In addition, environmental initiatives, such as self-generation of energy, can generate positive social impacts by allocating surpluses to schools, hospitals, and NGOs.

Among the threats, the lack of proof of ESG actions, especially in inclusion, diversity, and equity, stands out, which can generate perceptions of greenwashing and undermine institutional credibility. Stakeholder engagement is another critical factor, as low participation or misalignment between expectations and planned actions weakens social outcomes.

The inefficient integration of minority groups can also generate internal conflicts, especially in sectors historically dominated by men, such as agribusiness. In this context, strengthening the inclusive culture and structuring support channels become essential to mitigate risks and ensure the effectiveness of social actions.

Table 4

SWOT of external factors of the Social axis

External Factors	Positive Factors	Negative Factors
	Opportunities	Threats
	Expansion of training and scholarships (Cocal, 2024) Digital inclusion, literacy and accessibility projects for territorial development. Alignment with the SDGs. Donations of surplus renewable energy to socially focused organizations such as hospitals and NGOs.	Pressure for proof of diversity, equity, and inclusion in practices Resistance to diversity in traditionally male environments in the countryside. Inefficient integration of stakeholders into organizations' codes of conduct and/or ethics.

Source: Prepared by the author.

7 GOVERNANCE

In Tables 5 and 6, the SWOT methodology was applied to the Governance axis, in order to analyze internal characteristics (strengths and weaknesses) and external characteristics (opportunities and threats) related to rural producers in the sugar-energy sector.

7.1 INTERNAL FACTORS: STRENGTHS AND WEAKNESSES

The analysis of the governance axis of sugarcane producers in São Paulo shows initiatives aimed at ethical and responsible management, aligned with ESG guidelines and integrating environmental and social aspects. After Proálcool, the sector gained autonomy and began to adopt sustainable technologies and practices, initially focused on the environmental component, evolving to social and governance aspects due to economic and market pressures.

Currently, there is consolidation of decentralized structures, with committees dedicated to ethics, whistleblowing, and compliance, strengthening transparency and organizational integrity. Sustainability reports, whether internal or externally audited, ensure legal compliance and greater credibility. Certifications such as Bonsucro, GRI guidelines, and ABNT PR 2030 Standard encourage the adoption of ESG practices and provide a competitive advantage in the national and international market.

Among the weaknesses, ineffective stakeholder mappings stand out, which can compromise strategic planning, and gaps in cybersecurity, especially in the face of the General Data Protection Law (LGPD). There are also disparities in the implementation of governance practices between large, medium, and small producers, in addition to the absence of clear guidelines on unfair competition and corruption prevention, aspects that are still little addressed in industry reports.

Table 5

SWOT of the internal factors of the Governance axis

	Positive Factors	Negative Factors
	Strengths	Weaknesses
	Greater autonomy of sugarcane producing organizations after the end of PROÁLCOOL. Robust structure with ESG boards, committees, and reports (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). Ethics and integrity programs with active reporting channels (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023). National and international certifications, such as Bonsucro, RenovaBio, GRI. Transparent practices with audits and verified reports (Cocal, 2024; Delta Sucroenergia, 2024; Raízen, 2024; São Martinho, 2024; Ester Agroindustrial Plant, 2022; Lins Plant, 2023; São Manoel Plant, 2023).	Little approach to cybersecurity and IT vulnerabilities, despite initiatives such as the General Data Protection Law. Difficulty in adapting small producers to the requirements of formal governance of the mills. Low approach to unfair competition practices (<i>antitrust</i>) and the prevention of corruption. Mapping of <i>stakeholders</i> to prepare the sustainability strategy.

Source: Prepared by the author.

7.2 EXTERNAL FACTORS: OPPORTUNITIES AND THREATS

The opportunities in the governance axis of rural sugarcane producers in São Paulo are related to the adoption of sustainable corporate governance practices, which promote transparency, integrity, and alignment with ESG principles. The growing demand for investments in sustainable companies reinforces the need for robust governance structures,

capable of attracting investors and strengthening the institutional image, consolidating the competitive advantage.

The pressure for ESG practices also favors the creation of networks and strategic partnerships, involving innovation hubs, agricultural cooperatives, and universities, which offer training in corporate governance, digital tools, and management methodologies. The integration between rural producers and stakeholders contributes to standardizing sustainable practices, expanding the reach of ESG actions, and strengthening the organizational culture focused on sustainability.

The use of metrics and digital tools allows measuring the impact of governance actions, optimizing monitoring, ensuring transparency in sustainability reports, and strengthening internal control. This approach reduces regulatory risks and increases organizational credibility, which are essential for attracting investments and expanding business.

Among the threats are exposure to operational failures and reputational damage in case of non-compliance with ESG standards, as well as operational and strategic challenges such as legal uncertainty in the adoption of new practices and excessive bureaucracy in sustainability reports, especially for small and medium-sized producers.

Another challenge involves independent producers, who face limitations in training, access to digital technologies, and integrated audits, making it difficult to comply with ESG requirements and obtain certifications.

In summary, the adoption of ESG practices in the governance axis can consolidate competitive advantage, expand markets and attract investments, but requires standardization of processes, continuous training and mitigation of legal and operational risks to ensure the consolidation of corporate governance in the São Paulo sugar and alcohol sector.

Table 6

SWOT of the Governance axis

External Factors	Positive Factors	Negative Factors
	Opportunities	Threats
	Incentive to the professionalization of rural management with the support of cooperatives and hubs Use of digital tools and strategic management software (Raízen, 2024). Expansion of participatory and integrative governance in the field.	High reputational risk in case of failures in business conduct or ethics Rapid regulatory changes require flexible and up-to-date frameworks. Legal uncertainty or excessive bureaucracy can discourage progress. Independent producers may have difficulty

	Strengthening metrics for integrated reporting and strategic ESG. Attractiveness for investors with strategic planning of sustainable governance. Public access to sustainability and financial transparency reports.	accessing robust audits and certifications.
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Source: Prepared by the author.

8 CONCLUSION

The analysis shows that the application of ESG principles in the sugar-energy sector in São Paulo represents not only an instrument of environmental and social sustainability, but also a strategy for competitiveness in agribusiness. The use of the SWOT methodology made it possible to identify relevant forces, such as the advancement of the circular economy, the adoption of clean technologies, and the consolidation of governance structures, while revealing weaknesses, such as dependence on fossil fuels, social inequality, and the limitations faced by small producers. The opportunities associated with alignment with the Sustainable Development Goals, technological innovation, and access to international certifications reinforce the sector's expansion potential, while threats such as climate change, legal uncertainty, and reputational risks require mitigation strategies. It is concluded that the effective incorporation of ESG by sugarcane farmers requires integration between environmental, social, and governance practices, associated with institutional strengthening, innovation, and stakeholder participation, in order to consolidate a sustainable, resilient, and competitive production model in the national and international scenario.

The main limitation of this study is the dependence on secondary sources, especially sustainability reports from large mills, which can restrict the representativeness of small and medium-sized producers and introduce institutional bias. In addition, the absence of primary data and the lack of standardization in social and governance metrics limit the scope of the results.

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APPLICATION OF ESG GUIDELINES IN THE SUGAR AND ENERGY SECTOR: INTEGRATION BETWEEN GRI AND ABNT PR 2030

APLICAÇÃO DE DIRETRIZES ESG NO SETOR SUCROENERGÉTICO: INTEGRAÇÃO ENTRE GRI E ABNT PR 2030

APLICACIÓN DE LAS DIRECTRICES ESG EN EL SECTOR AZUCARERO Y ENERGÉTICO: INTEGRACIÓN ENTRE GRI Y ABNT PR 2030



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ABSTRACT

This study analyzes the development of sustainability reports in the sugar-energy sector, based on the integration of the Global Reporting Initiative (GRI) standards and the ABNT PR 2030 guidelines, focusing on the application of environmental, social, and governance (ESG) practices among rural producers of different sizes. The qualitative research was conducted through bibliographic and documentary review, including standards, sustainability reports, and scientific publications. Initially, the study contextualizes the economic relevance of the sugar-energy sector and the increasing demand for transparency and socio-environmental responsibility in agribusiness. It then addresses key concepts such as sustainability, ESG, stakeholders, and materiality, emphasizing the importance of standardization and reliability of information to avoid greenwashing practices. The results present guidelines for the preparation of sustainability reports, including the definition of material topics, the use of performance indicators, and the application of GRI standards. Additionally, a consulting model called SustentaAgro is proposed, aimed at providing technical support for ESG implementation and sustainability reporting, adapted to the different realities of producers. The study concludes that, despite progress in ESG adoption, significant challenges remain, particularly for small producers, mainly due to limited resources and lack of technical capacity, highlighting the need for accessible and context-adapted solutions.

Keywords: Sustainability. Materiality. Stakeholders. Governance. Indicators.

RESUMO

Este estudo analisa a elaboração de relatórios de sustentabilidade no setor sucroenergético, com base na integração das normas da Global Reporting Initiative (GRI) e das diretrizes da ABNT PR 2030, com foco na aplicação de práticas ambientais, sociais e de governança

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(ESG) em produtores rurais de diferentes portes. A pesquisa, de natureza qualitativa, foi desenvolvida por meio de revisão bibliográfica e documental, contemplando normas, relatórios de sustentabilidade e publicações científicas. Inicialmente, o trabalho contextualiza a relevância econômica do setor sucroenergético e a crescente demanda por transparência e responsabilidade socioambiental no agronegócio. Em seguida, aborda os conceitos de sustentabilidade, ESG, stakeholders e materialidade, destacando a importância da padronização e da confiabilidade das informações para evitar práticas de greenwashing. Como resultados, são apresentadas diretrizes para a elaboração de relatórios de sustentabilidade, incluindo a definição de temas materiais, utilização de indicadores de desempenho e aplicação dos padrões GRI. Além disso, propõe-se um modelo de consultoria, denominado SustentaAgro, voltado ao apoio técnico na implementação de práticas ESG e na elaboração de relatórios, adaptado às diferentes realidades dos produtores. Conclui-se que, apesar dos avanços na adoção do ESG, persistem desafios significativos, principalmente para pequenos produtores, relacionados à limitação de recursos e à falta de capacitação técnica, evidenciando a necessidade de soluções acessíveis e adaptadas ao contexto do setor.

Palavras-chave: Sustentabilidade. Materialidade. Stakeholders. Governança. Indicadores.

RESUMEN

Este estudio analiza la elaboración de informes de sostenibilidad en el sector de la caña de azúcar y el etanol, a partir de la integración de los estándares de la Iniciativa de Informes Globales (GRI) y las directrices ABNT PR 2030, centrándose en la aplicación de prácticas ambientales, sociales y de gobernanza (ASG) en productores rurales de distintos tamaños. La investigación cualitativa se desarrolló mediante una revisión bibliográfica y documental, que abarcó estándares, informes de sostenibilidad y publicaciones científicas. Inicialmente, el trabajo contextualiza la relevancia económica del sector de la caña de azúcar y el etanol y la creciente demanda de transparencia y responsabilidad socioambiental en la agroindustria. Posteriormente, aborda los conceptos de sostenibilidad, ASG, partes interesadas y materialidad, destacando la importancia de la estandarización y la fiabilidad de la información para evitar prácticas de ecoblanqueo. Como resultado, se presentan directrices para la elaboración de informes de sostenibilidad, incluyendo la definición de temas materiales, el uso de indicadores de desempeño y la aplicación de los estándares GRI. Además, se propone un modelo de consultoría, denominado SustentaAgro, orientado a brindar apoyo técnico en la implementación de prácticas ASG y en la elaboración de informes, adaptados a las diferentes realidades de los productores. Se concluye que, a pesar de los avances en la adopción de criterios ESG, persisten desafíos importantes, especialmente para los pequeños productores, relacionados con la limitación de recursos y la falta de capacitación técnica, lo que subraya la necesidad de soluciones accesibles y adaptadas al contexto del sector.

Palabras clave: Sostenibilidad. Materialidad. Partes Interesadas. Gobernanza. Indicadores.

1 INTRODUCTION

The cultivation of sugarcane has high economic relevance in the Brazilian context, positioning the country as the world's largest producer of this commodity. National production is predominantly concentrated in the Southeast region, with emphasis on the state of São Paulo, which brings together approximately 350 thousand rural producers operating in different segments of the production chain. This sector makes a significant contribution to the Gross Domestic Product (GDP), in addition to playing a significant role in job creation, exports, and the supply of food and energy, configuring itself as strategic for the national economy (Conab, 2025; Government of the State of São Paulo, 2023).

In recent decades, the concept of sustainability has been widely debated in the business, academic, and government spheres, with the purpose of promoting economic development in line with the conservation of natural resources. Such an approach presupposes the integration of the environmental, social, and governance dimensions, based on ethical and transparent practices that contribute to strengthening stakeholder trust and mitigating associated risks, such as greenwashing (França, 2024; Nascimento, 2022).

In this scenario, the concept of ESG (Environmental, Social, and Governance) emerges as a structuring model for the incorporation of sustainability in organizations, aligning with the Sustainable Development Goals (SDGs) and current international guidelines (Global Compact, 2025). However, the implementation of these practices in the agricultural sector still faces significant challenges, especially with regard to small producers, who often deal with limitations related to access to technology, information, and credit (Garcia, 2024).

The intensification of demands for transparency and socio-environmental responsibility has driven the adoption of sustainability reports as instruments for communicating organizational impacts and strengthening institutional credibility. In this context, the guidelines of the Global Reporting Initiative (GRI), widely recognized in the international scenario, stand out, as well as ABNT PR 2030, which adapts ESG principles to the specificities of the Brazilian context (Pineiro, 2023; Daub, 2007).

In view of the above, the present study aims to analyze and propose guidelines for the preparation of sustainability reports in the sugar-energy sector, considering the integration between the GRI standards and ABNT PR 2030, with emphasis on applicability for rural producers of different sizes. As specific objectives, it seeks to: (i) evaluate the applicability of these standards for small, medium and large producers; and (ii) propose a consulting model aimed at the implementation of ESG practices and the preparation of sustainability reports.

2 LITERATURE REVIEW

The demand for sustainable practices in the sugar-energy sector has shown significant growth, although there is still a predominance of studies focused on economic and productive aspects, to the detriment of social and governance dimensions. In this context, sustainability reports are relevant instruments for the evaluation and communication of organizational performance, although, in many cases, they remain focused on environmental and economic impacts (Silva, 2022).

The incorporation of ESG practices in agribusiness has gained prominence due to the need to reconcile productivity and sustainability, especially in the face of challenges such as deforestation and the growing demand for food. The adoption of these practices contributes to strengthening the resilience of production systems and promoting sustainability in the sector (Senar, 2023; Medeiros, 2023).

However, the implementation of ESG faces limitations related to the level of technical knowledge, access to resources, and the structural characteristics of rural producers, especially small-sized ones (Andrade, 2022). In this sense, the need for clear, standardized, and adaptable guidelines to the reality of the agricultural sector is evident.

ABNT PR 2030 is a recommended practice that guides Brazilian organizations in the adoption of sustainable practices, structuring ESG based on three main axes: environmental, social, and governance. This standard aims to reduce ambiguities and promote greater consistency in the application of ESG principles in the national context (ABNT, 2022).

In addition, the Global Reporting Initiative (GRI) establishes internationally recognized standards for the preparation of sustainability reports, enabling greater transparency, comparability, and credibility of the information disclosed. The adoption of these guidelines contributes to risk management, the strengthening of relationships with stakeholders, and the definition of strategic indicators (Global Reporting Initiative, 2025).

Sustainability reports play a central role in organizational communication, by highlighting the results and impacts of ESG practices, in addition to contributing to attracting investments and strengthening institutional reputation. However, the occurrence of greenwashing practices constitutes a relevant challenge, reinforcing the need for standardization and verification of the information disclosed (Albuquerque, 2023; Vieira, 2024).

In this context, stakeholders play a fundamental role in defining ESG strategies, influencing the identification of material topics and the prioritization of organizational actions. Continuous dialogue with these stakeholders enables greater alignment between the practices adopted and market expectations (Indriunas, 2023; Resende, 2024).

3 METHODOLOGY

The present study is characterized as a qualitative research, developed through a bibliographic and documentary review, based on scientific productions, institutional publications and sustainability reports related to the ESG theme in the agricultural sector.

The guidelines established by ABNT PR 2030 and the standards of the Global Reporting Initiative (GRI) were specifically analyzed, considering their applicability in the context of rural producers inserted in the sugarcane production chain. In addition, sustainability reports made available on institutional platforms of public access were examined, in order to understand practices already adopted in the sector.

The data analysis was conducted under an interpretative qualitative approach, aiming to understand the application of ESG practices and identify the main challenges and opportunities associated with their implementation. The literature review assumed an explanatory character, seeking to identify determining factors for the adoption of these practices in the agricultural sector (Gil, 2008; Manzo, 1971).

Based on this analysis, a support structure for the implementation of ESG was proposed, including the preparation of sustainability reports and the development of a consulting model based on the Business Model Canvas, aimed at the technical support of rural producers.

4 RESULTS

4.1 STRUCTURE FOR THE PREPARATION OF SUSTAINABILITY REPORTS

Sustainability reports represent an essential strategic instrument for organizational communication, allowing the systematized dissemination of practices, indicators, and results related to the environmental, social, and governance (ESG) dimensions. In the sugar-energy sector, these reports play an even more relevant role, considering the growing pressure for transparency and socio-environmental responsibility in agribusiness (Avila, 2023).

The structure of these reports, as established by the Global Reporting Initiative (GRI) guidelines, is based on the application of fundamental reporting principles, such as accuracy, balance, clarity, comparability, completeness, context of sustainability, timeliness, and verifiability. These principles guide not only the organization of information, but also ensure the consistency and reliability of the data presented (Global Reporting Initiative, 2021).

In the context of the sugar-energy sector, the specificity of the presentation of data by agricultural harvest is highlighted, which requires the maintenance of consistent methodologies over time. Comparability between production periods allows for the identification of variations in indicators, evaluation of the performance of the practices adopted, and establishment of more

assertive goals. This aspect reinforces the need for standardization in data collection and analysis, ensuring the continuity and reliability of the information reported.

The analysis of real reports, such as the one by São Martinho (2024), shows that the structure for the disclosure of general content (GRI 2) includes elements such as the identification of the organization, activities developed, value chain, governance, policies, and relationship with stakeholders. However, relevant gaps are observed in certain topics, such as the absence of details on governance appointment processes, remuneration policies, conflicts of interest, and performance evaluation of governing bodies, which compromises the completeness and transparency of information (São Martinho, 2024).

These results indicate that, although there is partial adherence to the standards, there are still challenges in the full implementation of the GRI requirements, especially with regard to the depth and quality of the information disclosed.

4.2 MATERIAL THEMES AND MATERIALITY MATRIX

The definition of material topics constitutes the central axis of the preparation of sustainability reports, as it guides organizational strategies and the prioritization of ESG actions. The identification of these topics must consider both the impacts generated by the organization and the expectations of stakeholders, reflecting the logic of double materiality (Global Reporting Initiative, 2021).

The use of the materiality matrix allows the topics to be classified according to their relevance to the company and stakeholders, organizing them into different levels of priority. The topics classified as high priority, such as climate change, greenhouse gas emissions, corporate governance, diversity and inclusion, human rights, and data privacy, represent those that require immediate and strategic action, and are directly incorporated into organizational planning (Global Reporting Initiative, 2021; Senar, 2023).

Medium-priority topics, such as water use, energy efficiency, waste management, organizational culture, and stakeholder engagement, require continuous monitoring and progressive improvement actions, while low-priority topics must be monitored, ensuring compliance with current legislation and standards (Brazilian Association of Technical Standards, 2022).

The analysis of the tables presented in the study shows a consistent ESG planning structure, including the definition of strategic objectives (OKRs) and performance indicators (KPIs) associated with each material topic. However, there is a need to improve this structure to fully comply with the guidelines of GRI 3: 2021, especially with regard to the explanation of

the methodological process for identifying and prioritizing the topics, as well as the inclusion of information on those responsible, monitoring periodicity, and data sources.

In addition, it is recommended to incorporate impact assessment criteria, such as scale, severity, and probability, allowing for a more robust analysis in line with regulatory requirements. These elements contribute to strengthening the methodological consistency and credibility of the sustainability report.

4.3 MANAGEMENT OF MATERIAL TOPICS AND USE OF INDICATORS

The management of material topics requires the definition of clear and measurable strategies, and the use of methodologies such as OKRs (Objectives and Key Results) associated with KPIs (Key Performance Indicators) is recommended. This approach allows the alignment of the organization's strategic objectives with operational indicators, facilitating the monitoring of ESG performance.

In high-priority themes, indicators are used to monitor critical aspects such as emissions reduction, energy efficiency, governance, and social inclusion. These indicators should be accompanied by specific targets, allowing progress to be assessed over time and guiding decision-making.

In medium-priority topics, indicators have a management and monitoring function, enabling continuous adjustments in organizational practices. In low-priority topics, indicators are used mainly for monitoring, ensuring that legal requirements are met, even if these topics are not strategic at the moment.

The adoption of this differentiated monitoring structure allows for a more efficient allocation of resources, directing efforts to the topics of greatest relevance and impact, without neglecting the other aspects of sustainability.

4.4 APPLICATION OF GRI STANDARDS AND TRANSPARENCY OF INFORMATION

The application of the Global Reporting Initiative (GRI) standards contributes significantly to the standardization of sustainability reporting, allowing greater comparability between organizations and strengthening the credibility of the information disclosed (Global Reporting Initiative, 2016; Global Reporting Initiative, 2021).

The GRI standards are structured into three main categories: universal, sectoral, and thematic. This framework enables a comprehensive approach to sustainability, allowing organizations to tailor reporting to their operational specificities.

Among the thematic standards, GRI 305 – Emissions stands out, which guides the disclosure of information related to greenhouse gases, including mitigation, compensation and monitoring strategies. The application of this standard is particularly relevant in the sugar-energy sector, due to its direct relationship with climate change (Global Reporting Initiative, 2016).

Transparency of information also involves the proper management of omissions, which must be justified in accordance with the criteria established by the GRI. The clear presentation of omissions, accompanied by justifications, contributes to the credibility of the report and demonstrates a commitment to transparency (Global Reporting Initiative, 2021).

In addition, the inclusion of the GRI content index and the statement of use of the standards makes it possible to organize the information and evidence the level of compliance of the report. Notification to the GRI about the use of the standards reinforces the legitimacy of the reporting process and evidences alignment with international standards.

4.5 ESG CONSULTING MODEL PROPOSAL

As a result of the analysis carried out, the creation of SustentaAgro Consultoria was proposed, a business model aimed at technical support in the implementation of ESG practices and in the preparation of sustainability reports in the sugar-energy sector.

The proposal considers the different realities of rural producers, offering solutions adapted to the size and needs of each audience. For small producers, simplified packages are suggested, with a focus on ESG compliance and basic training. For medium and large properties, as well as mills, more complete solutions are proposed, including audits, detailed reporting, and integration of ESG practices into corporate governance.

The model also includes the use of measurable ESG performance indicators, allowing continuous monitoring of the practices adopted. The proposal also includes the development of an interactive digital platform, with dashboards for monitoring indicators, automated generation of reports, and availability of educational content.

The hybrid service, combining remote support and technical visits, allows for greater proximity to producers and customization of solutions. In addition, the model provides for the formation of strategic partnerships with institutions and companies related to sustainability, as well as the use of the Business Model Canvas as a tool for structuring the business (Osterwalder; Pigneur, 2010).

In general, the results indicate that the consultancy's proposal has the potential to contribute to the dissemination of ESG practices in the sugar-energy sector, especially by offering accessible solutions adapted to the limitations faced by rural producers.

5 DISCUSSION OF THE RESULTS

5.1 IMPLEMENTATION OF ESG IN THE SUGAR-ENERGY SECTOR

The implementation of ESG practices in the sugar-energy sector is a complex process, which requires not only the adoption of normative guidelines, but also the adaptation of these practices to the productive and structural specificities of the sector. The analysis of the results demonstrates that the identification of material issues constitutes the basis for this implementation, being essential to guide the decision-making and strategic planning of organizations (Senar, 2023).

In this context, the use of ABNT PR 2030 as an initial reference presents itself as an appropriate approach to the Brazilian scenario, since this standard considers the particularities of the agricultural sector and allows for a gradual adaptation of ESG practices. On the other hand, the GRI offers a consolidated international standard, aimed at the standardization and communication of sustainability reports, evidencing the complementarity between both guidelines (Brazilian Association of Technical Standards, 2022; Global Reporting Initiative, 2022).

The integrated analysis of these standards shows that the implementation of ESG should not be treated as an isolated or one-off process, but rather as a continuous system, which involves diagnosis, planning, execution, and monitoring. This understanding reinforces the need to structure ESG as part of the organizational strategy, and not just as a compliance requirement.

5.2 INTEGRATION BETWEEN NORMS AND APPLICABILITY IN THE PRODUCTIVE CONTEXT

The results indicate that the integration between the GRI and ABNT PR 2030 standards allows for a more comprehensive and structured approach to sustainability, making it possible to align international standards with local conditions. This integration contributes to reducing the complexity of ESG implementation, especially by allowing producers to start their practices based on ABNT PR 2030 and progressively evolve towards the adoption of GRI standards.

However, it is observed that the applicability of these standards varies according to the size of the rural producer. While large organizations have a greater capacity to adapt, due to

access to resources, technology, and specialized teams, small producers face limitations that make it difficult to fully implement these guidelines (Garcia, 2024; Andrade, 2022).

This difference shows that the standardization proposed by the standards, although essential for comparability and transparency, can represent an operational challenge for producers with less technical and financial capacity. Thus, it is necessary to develop strategies that reconcile standardization with flexibility, allowing the adaptation of ESG practices to different production realities.

5.3 ROLE OF STAKEHOLDERS IN THE CONSTRUCTION OF ESG STRATEGIES

The analysis of the results shows that stakeholders play a central role in the construction of ESG strategies, directly influencing the definition and prioritization of material topics. The active participation of these actors, through mechanisms such as interviews, questionnaires, and structured dialogues, allows organizational practices to be aligned with social and market expectations (Global Reporting Initiative, 2021; Corrêa, 2024).

In addition, interaction with stakeholders contributes to the identification of risks and opportunities associated with productive activities, enabling a more efficient and strategic management of sustainability. This process also favors the construction of organizational legitimacy, as it demonstrates transparency and commitment to the demands of stakeholders (Indriunas, 2023).

However, the effectiveness of this engagement depends on the ability of organizations to establish adequate and accessible communication channels, which can represent an additional challenge for small producers, who do not always have formal relationship structures with stakeholders.

5.4 USE OF INDICATORS AND STRATEGIC PLANNING

The definition of ESG indicators, associated with the use of methodologies such as OKRs and KPIs, is a fundamental element for the operationalization of sustainability strategies. The analysis of the results demonstrates that the use of these instruments allows transforming abstract concepts into measurable metrics, facilitating performance monitoring and decision-making.

The materiality matrix plays a central role in this process, by allowing the prioritization of the most relevant topics and guiding the definition of strategic indicators. This approach contributes to a more efficient allocation of resources, directing efforts to the topics with the greatest impact.

However, it is observed that the definition and monitoring of these indicators require technical knowledge and access to structured data, which may limit their application in smaller rural properties. This scenario reinforces the need to simplify methodologies and specialized technical support, in order to enable the implementation of ESG in a broader and more inclusive way.

5.5 TRANSPARENCY, STANDARDIZATION, AND GREENWASHING RISKS

Information transparency emerges as one of the main pillars of sustainability, and is essential to ensure the credibility of reports and the trust of stakeholders. The adoption of GRI standards contributes to the standardization of information, reducing informational asymmetry and allowing greater comparability between organizations (Global Reporting Initiative, 2021).

However, the analysis of the results shows that the absence of standardization and incomplete disclosure of information can favor greenwashing practices, compromising the integrity of reports and the reputation of organizations. In this sense, the use of standards and certifications becomes essential to ensure the veracity of information and strengthen transparency (Vieira, 2024).

In addition, the obligation to justify omissions and the inclusion of elements such as the GRI content index and the declaration of use of the standards contribute to increasing the traceability of information and reducing risks of distortion in the communication of ESG practices.

5.6 FEASIBILITY AND CONTRIBUTION OF THE PROPOSED CONSULTING MODEL

SustentaAgro Consultoria's proposal arises as a response to the challenges identified in the implementation of ESG in the sugar-energy sector, especially with regard to the limitations faced by small and medium-sized producers. The analysis of the results indicates that the offer of specialized technical support can contribute significantly to the dissemination of ESG practices, making them more accessible and adapted to the reality of the sector.

The proposed model, by integrating tools such as performance indicators, digital platform and hybrid service, has the potential to facilitate the implementation of ESG practices and the preparation of sustainability reports. In addition, the segmentation of services according to the size of the producer allows to meet different levels of maturity and operational capacity.

Another relevant aspect refers to the possibility of integration between sustainability and production efficiency, showing that the adoption of ESG can generate benefits not only environmental and social, but also economic, contributing to the competitiveness of the sector.

Overall, the consultancy's proposal represents a viable alternative to overcome the barriers identified, promoting greater inclusion and strengthening the adoption of ESG practices in the sugar-energy sector.

6 CONCLUSION

The present study aimed to analyze the preparation of sustainability reports in the sugar-energy sector, based on the integration of the Global Reporting Initiative (GRI) standards and the ABNT PR 2030 guidelines, considering their applicability for rural producers of different sizes. From the literature and documentary review carried out, it was possible to understand that the adoption of ESG practices has been consolidated as a strategic element in agribusiness, especially in the face of the growing demand for transparency, socio-environmental responsibility and competitiveness in the market.

The results showed that the use of structured normative guidelines contributes to the standardization of sustainability reports, promoting greater reliability, comparability, and clarity of the information disclosed. In this context, GRI stands out as an international reference for reporting, while ABNT PR 2030 presents greater adherence to the Brazilian context, enabling a more accessible adaptation to the realities of the agricultural sector. The integration between these standards proved to be complementary, allowing for a progressive and structured approach to the implementation of ESG.

However, the analysis also highlighted the existence of significant challenges in the application of these practices, especially for small and medium-sized rural producers. Limitations related to access to financial resources, technology, information, and technical training hinder the full implementation of ESG guidelines, which can increase inequalities in the sector. This scenario reinforces the need for adapted solutions, capable of making sustainability more accessible and viable for different producer profiles.

Another relevant aspect refers to the importance of defining material topics and stakeholder engagement as central elements in the construction of ESG strategies. The use of tools such as the materiality matrix and the adoption of performance indicators allow for directing organizational actions, making the implementation process more structured and results-oriented. However, the effectiveness of these tools depends on the technical capacity of organizations, again highlighting the need for specialized support.

In this sense, SustentaAgro Consultoria's proposal is a relevant contribution to the study, by presenting a technical support model aimed at the implementation of ESG practices and the preparation of sustainability reports in the sugar-energy sector. The proposal seeks to meet the

different realities of producers, offering adapted solutions and promoting greater inclusion in the sustainable development process. In addition, the potential for integration between sustainability and production efficiency is highlighted, showing that the adoption of ESG can contribute to the generation of economic, social and environmental value.

In general, it is concluded that the integration between the GRI and ABNT PR 2030 standards represents a viable and strategic approach to the preparation of sustainability reports in the sugar-energy sector, contributing to the strengthening of transparency and governance in agribusiness. However, for this implementation to be effective and comprehensive, it is essential to consider the specificities of the sector and develop support mechanisms that enable the adoption of ESG practices by producers of different sizes.

Finally, it is recommended that future research advance in the empirical validation of the proposed model, through practical application in rural properties, as well as in the analysis of the economic feasibility of ESG practices. Such studies can contribute to broadening the understanding of the impacts of sustainability in the sugar-energy sector and strengthen its implementation in a more efficient and inclusive way.

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CARE AND PHYSIOTHERAPEUTIC INTERVENTION IN THE REHABILITATION OF ELDERLY PATIENTS ATTENDED IN PRIMARY HEALTH CARE: EXPERIENCE REPORT

CUIDADO E INTERVENÇÃO FISIOTERAPÊUTICA FRENTE A REABILITAÇÃO COM IDOSOS ATENDIDOS NA ATENÇÃO PRIMÁRIA A SAÚDE: RELATO DE EXPERIENCIA

CUIDADO E INTERVENCIÓN FISIOTERAPÉUTICA FRENTE A LA REHABILITACIÓN DE PERSONAS MAYORES ATENDIDAS EN LA ATENCIÓN PRIMARIA DE SALUD: RELATO DE EXPERIENCIA



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ABSTRACT

Introduction: This study describes the experience of a physiotherapist resident integrated into a multidisciplinary team within the Family Health Strategy (FHS) in the municipality of Quixeramobim, Ceará, Brazil, during the 2019–2020 period. It discusses the role of physiotherapy within the Brazilian Unified Health System (SUS), emphasizing health promotion, disease prevention, and rehabilitation actions carried out in an integrated manner with families and the community. Collective activities included prenatal groups, exercise programs for older adults, postural assessments, and follow-up of individuals with acute respiratory infections, among others.

Objective: To describe the experience of a physiotherapist in managing musculoskeletal pain in older adults participating in a health promotion program.

Methods: This is an experience report conducted over eight months, from August 2019 to March 2020, at the FHS unit Luís Prata Girão, located in the Conjunto Esperança neighborhood in Quixeramobim, Ceará.

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Results: The intervention led to a significant reduction in pain levels, decreased medication use, and improved social and family reintegration among participants.

Conclusion: The multidisciplinary team approach contributed to positive outcomes, high participant adherence, and strengthened comprehensive care. The inclusion of physiotherapy in primary health care proved essential for risk reduction, lifestyle modification, physical and psychosocial development, as well as for enhancing preventive and rehabilitative health actions.

Keywords: Physical Therapy. Primary Health Care. Family Health Strategy. Aged. Musculoskeletal Pain.

RESUMO

Introdução: Este artigo descreve a experiência de uma fisioterapeuta residente inserida em uma equipe multiprofissional na Estratégia Saúde da Família (ESF), no município de Quixeramobim-CE, no biênio 2019–2020. Discute-se o papel do fisioterapeuta no Sistema Único de Saúde (SUS), com ênfase nas ações de promoção da saúde, prevenção de agravos e reabilitação, desenvolvidas de forma integral junto às famílias e à comunidade. No âmbito coletivo, destacam-se atividades como grupos de gestantes, exercícios para idosos, avaliações posturais e acompanhamento de indivíduos com infecções respiratórias agudas, entre outras..

Objetivo: Descrever a vivência de uma fisioterapeuta no manejo da dor musculoesquelética em idosos participantes de um programa de promoção da saúde.

Métodos: Trata-se de um estudo do tipo relato de experiência, desenvolvido ao longo de oito meses, entre agosto de 2019 e março de 2020, na unidade da ESF Luís Prata Girão, localizada no bairro Conjunto Esperança, no município de Quixeramobim-CE.

Resultados: Observou-se redução significativa da dor relatada pelos participantes, diminuição do uso de medicamentos e melhora na reinserção social e familiar dos idosos.

Conclusão: A atuação da equipe multiprofissional contribuiu para resultados positivos, com boa adesão dos participantes e fortalecimento do cuidado integral. A inserção do fisioterapeuta na atenção básica mostrou-se fundamental para a redução de riscos, promoção de mudanças no estilo de vida, desenvolvimento físico e psicossocial, além de potencializar ações de prevenção e reabilitação em saúde.

Palavras-chave: Fisioterapia. Atenção Primária à Saúde. Estratégia Saúde da Família. Idoso. Dor Musculoesquelética.

RESUMEN

Introducción: Este artículo describe la experiencia de una fisioterapeuta residente integrada en un equipo multiprofesional en la Estrategia de Salud de la Familia (ESF), en el municipio de Quixeramobim-CE, durante el bienio 2019–2020. Se discute el papel del fisioterapeuta en el Sistema Único de Salud (SUS), con énfasis en las acciones de promoción de la salud, prevención de enfermedades y rehabilitación, desarrolladas de forma integral junto a las familias y la comunidad. En el ámbito colectivo, se destacan actividades como grupos de gestantes, ejercicios para personas mayores, evaluaciones posturales y seguimiento de individuos con infecciones respiratorias agudas, entre otras.

Objetivo: Describir la vivencia de una fisioterapeuta en el manejo del dolor musculoesquelético en personas mayores participantes de un programa de promoción de la salud.

Métodos: Se trata de un estudio de tipo relato de experiencia, desarrollado a lo largo de ocho meses, entre agosto de 2019 y marzo de 2020, en la unidad de la ESF Luís Prata Girão, ubicada en el barrio Conjunto Esperança, en el municipio de Quixeramobim-CE.

Resultados: Se observó una reducción significativa del dolor reportado por los participantes, disminución del uso de medicamentos y mejora en la reinserción social y familiar de las personas mayores.

Conclusión: La actuación del equipo multiprofesional contribuyó a resultados positivos, con buena adherencia de los participantes y fortalecimiento del cuidado integral. La inserción del fisioterapeuta en la atención primaria se mostró fundamental para la reducción de riesgos, promoción de cambios en el estilo de vida, desarrollo físico y psicosocial, además de potenciar acciones de prevención y rehabilitación en salud.

Palabras clave: Fisioterapia. Atención Primaria de Salud. Estrategia de Salud de la Familia. Persona Mayor. Dolor Musculoesquelético.

1 INTRODUCTION

The Unified Health System (SUS) is based on the Federal Constitution of 1988, which establishes, through article 196, that health is a right of all and a duty of the State. Its organization is based on a decentralized management model, structured at the federal, state and municipal levels, in addition to being organized according to the levels of complexity of primary, secondary and tertiary care (BRASIL, 1990).

In this context, in 1997, the Family Health Program (PSF) was instituted in the state of Ceará, through Decree No. 10,104/97, with the objective of expanding access to health services and reducing inequalities. The program's main characteristic was the reorganization of the work process in primary care, promoting a new logic of care centered on the family and the territory (ESMERALDO, 2009).

Later, in 2006, the PSF was reformulated and was renamed the Family Health Strategy (FHS), consolidating itself as a strategy for the reorganization of primary care, with multidisciplinary actions planned based on local needs (BRASIL, 2008).

With the expansion of the FHS throughout the national territory, driven by incentives from the Ministry of Health, this strategy came to be recognized as the main gateway to the SUS. The FHS plays a fundamental role in the first contact with the user, in the continuity and coordination of care, constituting the basis for the organization of health care networks, with the support of the different levels of care (FAUSTO et al., 2014).

The expansion of the scope of actions in primary care was also strengthened with the creation of the Family Health Support Center (NASF) in 2008, which enabled the inclusion of different professional categories, including physiotherapists, with the aim of expanding the problem-solving capacity and scope of the ESF teams (BRASIL, 2008; GONÇALVES, 2015). However, the NASF was discontinued in 2020, according to Technical Note No. 3 of the Department of Family Health, linked to the Secretariat of Primary Health Care (MASSUDA, 2020).

In this scenario, the physiotherapist assumes an essential role in primary care, acting in the dimensions of health promotion, disease prevention and rehabilitation, in an integral way and articulated with the needs of families and the community. Its activities also extend to the collective sphere, through activities such as groups of pregnant women, exercise programs for the elderly, postural assessments and monitoring of individuals with acute respiratory infections, among other actions (MACIEL et al., 2005).

Specifically in the care of the elderly population, the role of the physiotherapist is essential for maintaining quality of life and functional capacity, respecting the limitations inherent

to the aging process. The implementation of exercises and therapeutic activities contributes to the promotion of autonomy in activities of daily living. Considering that musculoskeletal pain is highly prevalent in this population and directly impacts functionality, it is essential for the professional to have qualified intervention to minimize such problems (MACIEL et al., 2005).

Thus, this article aims to describe the experience of a resident physiotherapist inserted in a multiprofessional team of the Family Health Strategy, in the biennium from 2019 to 2020, addressing her performance in the face of musculoskeletal pain in elderly participants in a health promotion program.

2 METHODS

This is a descriptive study, of the experience report type, which aims to present and reflect on the professional practice developed in the context of primary health care. The experience was lived over eight months, from August 2019 to March 2020, in the municipality of Quixeramobim, located in the state of Ceará.

The setting of the experience was the unit of the Family Health Strategy (FHS) Luís Prata Girão, located in the Conjunto Esperança neighborhood, a territory characterized by demands related to chronic health conditions, social vulnerabilities and high demand for care aimed at rehabilitation and pain management. The experience was conducted by a resident physiotherapist linked to the Family and Community Health Residency Program of the School of Public Health of Ceará, inserted in a multiprofessional team, during the 2019–2021 biennium.

The report is based on working with a group of elderly people monitored by the FHS team, whose referrals occurred mainly due to complaints of musculoskeletal pain, functional limitations and impaired autonomy in activities of daily living. The identification of users and their direction to the group were carried out by the different professionals of the team, such as nurses, psychologists and social workers, based on qualified listening and the assessment of the needs presented during individual and collective care.

The organization of the group occurred in a shared way among the members of the multiprofessional team, with physiotherapy playing a leading role in the planning and execution of interventions aimed at the comprehensive care of the elderly population. Initially, the participants were submitted to an individual evaluation, including detailed anamnesis and kinetic-functional examination, with the objective of identifying limitations, potentialities and specific demands of each individual.

Based on these evaluations, interventions based on physiotherapeutic conducts aimed at health promotion, disease prevention and functional rehabilitation were structured. The

activities included muscle stretching exercises, active-assisted and active exercises, progressively adjusted according to the evolution of the participants, focusing on muscle strengthening, mobility gain, balance improvement and pain reduction. In addition, health education strategies were incorporated, addressing topics such as self-care, posture, fall prevention, and the importance of regular physical activity.

The group also included integrative body practices, fine and gross motor training and recreational activities, aiming not only at the physical aspects, but also at strengthening bonds, socialization and the psychosocial well-being of the participants. This expanded approach sought to consider the elderly in their entirety, respecting their limitations and encouraging their autonomy.

The meetings took place every two weeks, totaling 16 sessions over the period described, with an average duration of 50 minutes each. The activities were conducted by a physiotherapist, with occasional support from the multiprofessional team, and had the average participation of 15 elderly people per meeting.

The systematization of the report was built from observations of practice, records of the activities developed and critical reflections on the care process in the context of primary care, considering the challenges and potentialities of the insertion of physiotherapy in the Family Health Strategy.

3 RESULTS

The performance of Physical Therapy in primary care ranges from health promotion to rehabilitation, with the aim of maintaining and/or returning this functional patient to society. The physiotherapist, when working in primary care within a group, where the participants are functionally limited and have different diagnoses, is challenging for the professional.

The organization was essential for the execution of the project, capturing these patients who are active in the networks, following the flow of care is delicate, as it requires a holistic look to perceive their needs, providing more to those who need more is indispensable when it comes to health, equity is necessary when it comes to a better quality of life.

The participants were monitored in the health devices and through their complaints, the professionals indicated it and referred the group verbally, there was no need for a reference form and counter-reference, leaving the organizational and strategic principles of the SUS, which could lose bonds, interrupting the integrality of care. However, everyone was very assiduous and interested in the group. The services were collective, in a large room, where all the activities were carried out.

In the first contact, we conducted an interview to find out what the main complaints of these patients were and what led them to be interested in participating in the group. During the interview, all of them reported that the drug treatment was not enough and that they had frequent pain that prevented them from performing simple daily activities.

Five of the participants had a clinical diagnosis of depression, were being monitored by a psychologist and psychiatrist. And 10 had a clinical diagnosis of fibromyalgia. All had in common musculoskeletal pain that limited their functions and decreased their independence.

The records were made in the field diary. The greatest relevance is the reduction of pain, increased functionality and autonomy that the patients reported from the third meeting of the group. The exercises of strengthening, gain of amplitude, stretching, balance and coordination were carried out individually through the verbal command and demonstration of the Physiotherapist.

At first, during the evaluation, most participants reported a lot of pain and through the Visual Analogue Scale (VAS), which helps in the quantification of pain, where 0 is no pain and 10 is exacerbated pain, most indicated from 7 to 10 the level of pain and after the third meeting decreased to 4 to 7, Through the participants' reports and the progression of the exercises, we realized that the objectives set were being achieved

4 DISCUSSION

Quality of life, according to Soares et al. (2020), is functional capacity together with the general state of physical and mental health added to social aspects of the context in which the individual is inserted. In view of this, Júnior et al (2019) bring that the promotion of quality of life can be done through collective activities and a mobilizing environment, which can thus preserve their physical, mental, and social capacities.

Inactivity in old age directly impairs the ability and execution of daily activities. In addition to interfering with the quality of life of individuals who will go through situations such as loneliness and associated diseases that generate some negative feedback and/or physical limitations. (SOARES et al., 2020)

The role of the physiotherapist begins with touch, which is the main work tool of physiotherapy, as it incorporates a very intimate relationship with the body, capable of influencing the quality of care, care and treatment of patients. However, their performance also involves the guidance and promotion of their patient's health (JAMARIM, 2016).

The physiotherapy professional helps in the process, whether in terms of assistance, rehabilitation, education and/or with a view to health surveillance in order to minimize the

possible problems caused by the lack of specialized assistance (PEREIRA; GESSINGER, 2014). When a physiotherapist attends a rehabilitation patient, for Logan et al. (2004), the final phase is the most difficult of the process, due to the trauma suffered by these patients in many cases, limiting the performance of several tasks. In this sense, primary care health professionals play a crucial role in controlling the needs of each patient in addition to encouraging them.

Referral and Counter-referral in Health are mechanisms of the Unified Health System (SUS), which favor the exchange of information in the care network, the user's transit in the system and the continuity of care. This is essential in the relationships of the networks (ANDRADE, 2019).

We still witness several challenges faced by the FHS team, with the precariousness of labor relations related to overwork and salaries incompatible with the professionals' wishes. (NOGUEIRA et al., 2019).

During the meetings, we realized that sharing experiences was a primary factor, sometimes even more important than physical activities. In which the act of talking and sharing both with professionals and peers helps in the sense of well-being and general motivation of the users participating in the group. When we opened a conversation circle, those patients previously reported indisposition, pain and incapacity, after conversations, clarifications, welcoming, they left there able to develop their activities, and the study by Rezende et al. (2007) confirms this, the interaction with the patient and the multidisciplinary team has a positive impact, making the therapy more pleasurable, putting humanization into practice, taking into account the entire social context and not only the biological issues.

Peduzzi and Agreli (2018) talk about the importance of welcoming, of talking to the patient during care. It reports the importance of a Physical Therapist identifying and knowing how to understand atypical manifestations, actions, reactions that are persistent during the patient's evaluation and take into account in their conduct.

We professionals evaluate and treat musculoskeletal, neurological, behavioral and related disorders, sometimes not seeing beyond what is seen, the pain that the patient reports, negatively impacting their results. According to Boesch (1977), this occurs because it is the professional's routine to do the same thing every day, leading us to neglect signs, worrying only about solving the complaint about physical limitation, refusing to see the circumstances around and states that this is due to the fact that the professional believes that a good reception and listening is not part of his training.

As shown in their study, Besset et al. (2010), chronic pain has three elements that constitute the psychic: feeling of uselessness, failure to reduce pain, and rejection itself for going

through all this. In the meetings it was possible to notice these 3 elements, the patients talked a lot about not being able to resolve what they felt and still living with the judgment of victimhood, despite not being able to work because the pain made it impossible for them. They also carried the guilt of going through this alone and in the group they were able to see and live with people who were going through the same situation, making them resignify this feeling.

As already discussed above, a significant improvement of patients was perceived in various areas of their lives, social, family, reduction of pain, with consequent improvement in quality of life, corroborating these results with the findings of Silva et al. (2012) where they showed that amplified and humanized care reduced the patient's persecution, pain and the situation in which they found themselves, that actions in groups and directed made them recover their functions and their role in society, identifying themselves in the other contributed to improvement, in addition to the welcoming of the multiprofessional team and interdisciplinary work.

In this way, teamwork is able to resignify health acts, thus making care more committed to the democratization of labor relations and valuing health professionals (SANTOS et al., 2016)

5 FINAL CONSIDERATIONS

After this report of experience and coexistence with this group, the difficulties and limitations that the elderly still face in the twenty-first century in the country in public health were observed. We believe that precisely at this point lies a problem, there is a need for a general understanding that encompasses teams and government, which often do not realize the importance of preventive work with investment of financial and human resources in the old age segment, since we have an increasing picture of an aging population around the world. Family Health professionals make a big difference in terms of care and a broader view, bringing solutions to their daily sufferings for individuals. However, many concerns have permeated during the trajectory of this research on this theme that I will seek to answer in future research.

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VERTICAL INTEGRATION IN THE APPLICATION OF PESTICIDES IN BRAZIL: A GOVERNANCE PROPOSAL FOR REDUCING SANITARY AND ENVIRONMENTAL RISKS

INTEGRAÇÃO VERTICAL NA APLICAÇÃO DE AGROTÓXICOS NO BRASIL: PROPOSTA DE GOVERNANÇA PARA REDUÇÃO DE RISCOS SANITÁRIOS E AMBIENTAIS

INTEGRACIÓN VERTICAL EN LA APLICACIÓN DE PLAGUICIDAS EN BRASIL: UNA PROPUESTA DE GOBERNANZA PARA REDUCIR LOS RIESGOS SANITARIOS Y AMBIENTALES



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ABSTRACT

This article analyzes the public health and environmental risks associated with pesticide use in Brazil and discusses how governance arrangements can influence the quality of on-farm application. Through a comparative literature review of three models (direct sales, outsourcing, and downstream vertical integration), the study synthesizes evidence on recurrent shortcomings in use (dosage, personal protective equipment, disposal, and resistance management), particularly in settings with limited technical assistance. It proposes an industry-linked technical application service model incorporating mechanisms for traceability, operational standardization, and accountability. The article concludes that a partial shift from a sales-based model to a service-based model can reduce risks, provided it is accompanied by regulation, independent auditing, and safeguards for smallholders.

Keywords: Vertical Integration. Agrochemicals. Sustainability. Environmental Hazards.

RESUMO

Este artigo analisa riscos sanitários e ambientais associados ao uso de agrotóxicos no Brasil e discute como arranjos de governança podem influenciar a qualidade da aplicação no campo. Por meio de revisão bibliográfica (venda direta, terceirização e integração vertical a jusante), sintetizam-se evidências sobre falhas recorrentes de uso (dosagem, EPI, descarte e manejo de resistência), especialmente em contextos de baixa assistência técnica. Propõe-se um modelo de prestação de serviço técnico de aplicação vinculado à indústria, com mecanismos de rastreabilidade, padronização operacional e responsabilização. Conclui-se que a migração parcial de um modelo de venda para um modelo de serviço pode reduzir riscos, desde que acompanhada de regulação, auditoria independente e salvaguardas para pequenos produtores.

Palavras-chave: Integração Vertical. Agroquímicos. Sustentabilidade. Perigos Ambientais.

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RESUMEN

Este artículo analiza los riesgos para la salud y el medio ambiente asociados al uso de plaguicidas en Brasil y examina cómo los mecanismos de gobernanza pueden influir en la calidad de su aplicación en el campo. Mediante una revisión bibliográfica (ventas directas, subcontratación e integración vertical descendente), se sintetiza la evidencia sobre fallas recurrentes en el uso (dosificación, EPI, eliminación y manejo de la resistencia), especialmente en contextos con escasa asistencia técnica. Se propone un modelo para la prestación de servicios técnicos de aplicación vinculados a la industria, con mecanismos de trazabilidad, estandarización operativa y rendición de cuentas. Se concluye que una transición parcial de un modelo de ventas a un modelo de servicios puede reducir los riesgos, siempre que se acompañe de regulación, auditorías independientes y salvaguardias para los pequeños productores.

Palabras clave: Integración Vertical. Agroquímicos. Sostenibilidad. Riesgos Ambientales.

1 INTRODUCTION

Brazil is one of the main agricultural producing countries in the world. In 2018, the participation of Agribusiness reached 21.1% of the Brazilian GDP, it is the world's largest producer of coffee, orange juice and chicken meat and second in the production of sugar, soybeans and beef. Simultaneously with this, agribusiness was responsible for 87.6 billion of the Brazilian trade balance, ensuring its positive balance of 58.7 billion. Brazil is the world's leading exporter of sugar, coffee, orange juice, soybeans, chicken and beef, the second largest exporter of soybean oil, soybean meal and cotton, and is among the main exporters of corn and pork (CNA, 2019).

The success of Brazilian agribusiness in agricultural production, assuming great prominence in the international scenario, was guided by successful policies for agriculture, such as investment in research, rural credit, price policies, tax policies, investment policies, export stimulus policy, etc. In the field, new varieties of crops were implemented, adjusting to edaphoclimatic factors, zoning, investments in machinery, equipment, implements, seeds, fertilizers, limestone, agrochemicals and new management techniques. Not only in the field, but adjustments and new methodological and management techniques were implemented throughout the production chain, especially for commodities (CHADDAD, 2017).

As an example, the trend of increase in Brazilian grain production and productivity is being consolidated in recent decades. From the 1976/1977 harvest to the 2018/2019 harvest, there was an increase in the produced area in the order of 1.2% per year, while productivity increased by 2.6% per year and production by 3.9% per year (CONAB, 2019).

Among the actions carried out to increase productivity in the field, the mechanisms to combat pests and diseases stand out, in addition to being one of the pioneers to implement the use of biological control on a large scale in crops, Brazil has advanced in the development of agrochemicals,² which are chemical substances used in agricultural crops with the objective of preventing, destroy, repel or inhibit the occurrence or effect of living organisms that can compromise the performance of agricultural crops (NATIONAL RESEARCH COUNCIL, 2000).

There are about 300 active ingredients, in two thousand different commercial formulations, used in the country. The main agrochemicals are Herbicides, Insecticides, Fungicides, Acaricides, Biological control agents, semiochemical-based agrochemicals, fumigants, rodenticides, molluscocides, nematocides and Household products (SILVA and COSTA, 2012; STOPPELLI AND MAGALHÃES, 2005).

² Also known as pesticides, pesticides, pesticides or phytosanitary products.

According to FAO (2019), from 1990 to 2017, the use of agrochemicals in the world grew at a rate of 2.12% per year; in Brazil, use has been increasing at a rate of 7.5% per year. According to this same source, the country is the third largest consumer in the world with 8.44% of the volume used, it is second in the use of insecticides and herbicides, and third in the consumption of fungicides.

These increasing rates of agrochemical use in Brazil are due to the new technologies used in the field to increase crop productivity. However, it can also be due to the inappropriate use and management of available technologies, leading to the waste of developed technological efficiency. In fact, there are studies that point to serious problems such as the emergence of pest resistance to active ingredients, as a result of inappropriate use, in addition to the widely discussed implications

According to Almeida (2018), rural producers should consider adopting resistance management strategies on their properties, as inadequate management in the use of agrochemicals can compromise the profitability of rural producers, generating a loss of efficiency in the technology used and increasing pest resistance. This generates an increase in the application of the volume of agrochemicals necessary for the crop, causing economic losses, losses of the technological benefit of agrochemicals in terms of their effectiveness in the field.

One of the problems identified within agricultural production is the level of education of rural producers, of the 5,056,525 agricultural establishments, 23.03% of the owners do not know how to read and write, 79.98% do not receive any technical guidance and only 33.15% used agrochemicals, according to data from the 2017 Agricultural Census. Of those who used agrochemicals, 15.58% do not know how to read and write, 77.09% do not have a high school education, and 63.29% did not receive technical assistance (IBGE, 2019).

With these data from the last Agricultural Census, it can be seen that the process of managing agrochemicals in the field needs to be better oriented towards reducing risks in the health of producers, consumers and environmental risks.

From the producer it would be in the correct handling in the field and for his own protection; however, most of them do not have the level of education or access to the technical assistance necessary for the correct management of the use and application of agricultural pesticides, in addition to the adoption of integrated management and other more sophisticated and sustainable techniques that require greater knowledge;

From the consumer, with the incorrect administration of agrochemicals in the field, it is possible to consume products that do not respect the rules for the use of agrochemicals, either

by the use of chemicals in inadequate doses or by disrespecting the grace period, or even by applying products not registered for the crop. This, in part, is inspected by ANVISA through the Program for the Analysis of Pesticide Residues in Food (PARA) (ANVISA, 2019).

Environmental risks, depending on the toxicity of the agrochemical, the form of application, the amount or dose used, can compromise the soil, subsoil, surface and groundwater, and the entire ecosystem (BRASIL, 2020; SPADOTTO et. al, 2004)

Outsourcing the application of agrochemicals could be one of the ways to reduce risks. This form of service is provided for in Federal Law No. 7,802/1989 in its Article 4, and in Federal Decree No. 4,074/2002, which says that both individuals and legal entities can provide services in the application of agrochemicals, as long as all legal criteria are observed. However, within this outsourcing process, it is possible to find companies that do not comply with the legislation, and it is common for the responsible bodies to suspend their licenses, that is, it cannot be said that outsourcing guarantees the reduction of health and environmental risks (SEAPDR, 2020; ANVISA, 2019; BAMFORD, 2015; MIOLA, 2013; MARQUES, 2005).

Faced with the new challenges regarding the use of agrochemicals in Brazilian agriculture, the National Congress (NC) has discussed and processed the Bill (PL) 6299/02, which deals with the registration, inspection and control of agrochemicals in the country, with the objectives of reducing bureaucratic dysfunctions in the registration process until its applicability in the field, health risks and environmental risks. However, this project has received resistance from the National Health Surveillance Agency (ANVISA), which according to ANVISA, withdraws its competence to carry out toxicological and environmental assessment. This bill is already ready to be discussed in the plenary of the NC (BRASIL, 2018; ANVISA, 2018).

According to the Embrapa Agency for Technological Information (2020) and Spatolo et. al (2004), Brazil is a tropical country and has several crops and crops throughout the year of various agricultural products, which favors the incidence of pests and diseases; along with this, the inappropriate use of chemical products, the lack of technical preparation to adopt an integrated management resulting in products that can generate health and environmental risks. Consequently, it is necessary to point out a managerial solution that involves a change in the coordination relations in part of the production chain.

Therefore, this work aims to suggest the possibility of Vertical Integration in the application and administration of agrochemicals in the field.

2 METHODOLOGY

2.1 STUDY DESIGN

This study adopted an exploratory and qualitative approach, combining a review of narrative literature with a comparative method, with the objective of analyzing how different governance models associated with the use and application of agrochemicals can influence health and environmental risks and productive/economic implications.

The comparative method allows us to examine similarities and differences between institutional and economic arrangements, highlighting relevant relationships between analyzed elements, with the potential for analytical generalization when applied systematically (GIL, 2008; MARCONI; LAKATOS, 2003). Thus, the study structured the study through empirical evidence and available institutional references.

2.2 UNITS OF COMPARISON: GOVERNANCE MODELS ANALYZED

Governance models of the use and application of agrochemicals in the Brazilian context were analyzed in a comparative way:

1. Direct sales to producers;
2. Outsourcing of the application by individuals or legal entities, provided for in Law No. 7,802/1989 and related regulations.
3. Vertical integration downstream by the industries, as a managerial proposition, in which the supply of the input is articulated with the provision of technical service of application and monitoring in the field.

The comparison was guided by the recurring challenges pointed out in the literature and in the public debate, including aspects such as the use of PPE, handling and disposal, training/technical assistance, resistance management, regulatory compliance, and risks of contamination in workers, food, and the environment.

2.3 NARRATIVE LITERATURE REVIEW: SCOPE AND SELECTION OF MATERIAL

A narrative review was carried out (CORDEIRO et al., 2007; ROTHER, 2007) in order to map national and international empirical evidence related to:

- health and occupational risks associated with the use of agrochemicals;
- environmental risks (soil, water, ecosystems) and operational factors that increase exposure;
- recurrent failures in the application (training, reading of labels and package inserts, PPE,

- disposal of packaging, inadequate handling);
- residue monitoring and compliance in food.

As it is a narrative review, the selection of the material was intentional and not exhaustive, guided by the pertinence to the research problem and by the contribution of the studies to describe risk mechanisms and operational conditions associated with the application.

Within this scope, empirical studies such as those by Schmidt and Godinho (2006), Veiga et al. (2007), Malaspina et al. (2011), Bedor et al. (2009), Casali et al. (2015) and Petermann et al. (2019) were mobilized, among others, as they address complementary dimensions of the problem (poisoning/underreporting, PPE, epidemiological profile, social vulnerabilities, training and food residues).

2.4 SECONDARY DATA AND INSTITUTIONAL SOURCES

In addition to the academic literature, the study used secondary data and information from institutional databases for contextualization and analytical support of the Brazilian scenario, including sources such as:

- 2017 Agricultural Census (IBGE, 2019 publication);
- databases and reports from agencies and institutions related to regulation and monitoring (e.g., ANVISA, including waste monitoring programs);
- agricultural production and productivity bases and sectoral context (e.g., CONAB, FAO, Embrapa).

These sources were used to support the characterization of the productive and regulatory context and to reinforce the interpretation of the evidence discussed in the literature review, without pretense of causal statistical inference.

2.5 STUDY LIMITATIONS

This study has limitations inherent to the adopted design:

- as it is a narrative review, there is no claim of exhaustiveness or formal synthesis goals;
- the comparison between models configures a conceptual and interpretative analysis, based on secondary evidence and selected literature;
- Primary collections (e.g., interviews, surveys, or case studies) were not conducted, which restricts inferences about operational feasibility, costs, and measurable impacts in specific contexts.

Even so, the design is adequate to the exploratory objective of discussing governance alternatives and their possible implications for the reduction of health and environmental risks.

3 RESULTS AND DISCUSSION

3.1 VERTICAL INTEGRATION

According to Zylbersztajn and Neves (2000), market competition is the necessary stimulus for companies to seek to reduce costs in an Economic System. For this, companies belonging to a competitive market structure adopt several strategies, such as competition strategies (price formation, collusion, price war, sunk costs); growth strategy (acquisition, mergers, market segmentation, differentiation, diversification and vertical integration).

These authors state that vertical integration is a particular type of diversification of a company's growth strategy. The company's objective in adopting this strategy is to acquire greater control in the production chain to reduce costs, employ strategic actions against rival companies and better explore the market for products downstream in the production chain.

Vertical integration within the agro-industrial context is defined as a set of activities of the links in the production chain, assuming previous and/or subsequent stages of some process within the agricultural production chain. In Brazil, the most common integrations are the chain of poultry, pork, seeds, vegetables (industrial tomatoes and peas), silks, flowers addressing various systems or part of the production process (ARAÚJO, 2013).

According to Batalha (2014), vertical integration becomes attractive to sectors that identify cost reduction, appropriate market profits, favor the company's main activity, obtain greater control of operations and strategies to be adopted. However, according to the author, it can increase the risk of the integrating company, and it can also bring greater concerns about bureaucratic dysfunctions and divert the main focus from the company's management.

Vertical integration can reduce or save expenses with taxes, uncertainties, that is, it aims to reduce exchange relationship costs, migrating this market transaction relationship into the company. Vertical integration can be done upstream (e.g., a company that acquires a distributor of inputs, machinery, and equipment) or downstream (e.g., a company acquires logistics control or networks of companies oriented to the end consumer), for this type of strategy to be efficient, it is necessary to establish contracts and conduct agreements with customers and key partners to sustain minimum levels of products and inputs (ZYLBERSZTAJN; NEVES and CALEMAN, 2015).

Vertical integration can be done downstream or upstream in the production chain. When the company seeks forward integration, it seeks to differentiate the product, have better access

to marketing channels, better access to market information, improve distribution and take advantage of higher prices of products or services. In the case of backward integration, the company seeks to patent inputs, replace inputs purchased from other companies and start to supply its own input with the desired standard and quality, differentiating itself in the market (PORTER, 2004; KON, 2017).

Integration contracts are provided by Federal Law No. 13,288, of May 16, 2016, which aims to guarantee contracts and relationships of obligations and responsibilities between integrated producers and integrators. Its 14 articles establish the relationships, permissions, prohibitions, technical parameters, deadlines, rights and duties of the contract and procedures that each interested party must correspond to (BRASIL, 2016).

According to Stern et al. (1996), there are several reasons for companies to seek the vertical integration strategy, such as the complex characteristics of buying inputs or selling products; the high cost of changing suppliers or partners; the need for chain coordination to ensure product quality; uncertain environment; Transactions flow easily and with high frequency.

As an example of research that developed empirical studies of this market strategy, we find the works of Kilmer, Andre and Stevens (2001) who analyzed the relationship between vertical integration and pesticide residues in strawberries and tomatoes in the state of Florida-USA. Sologuren (2004) sought to identify the advantages of soybean processing companies in adopting vertical integration in the acquisition of fertilizer companies as a form of competitive advantage.

Lima et. al. (2009) sought to understand the strategy adopted by a pulp and paper company and identified the possible advantages and risks associated with the strategy employed. Lima (2011) identified the competitive challenges for the family oilseed agroindustry in the semi-arid region of Bahia by adopting verticalization. Marques, Souza and Machado Júnior (2015) sought to describe the arrangement determined in the Microregion of Anápolis - GO for the integrated production of chicken under the competitive strategy of verticalization of operations.

Araújo (1996) calculated the profitability of broiler chicken production that had vertical integration contracts in the State of Minas Gerais. De Souza (2007) investigated the reasons for the agro-industrial sector of grain processing in Brazil to adopt as a vertical integration strategy. Proença (2012) analyzed, from the 2000s onwards, the growth of the sugarcane sector in the mesoregion of Araçatuba and ascertained the possibility of increased industrial concentration in the sector and whether companies were strategically adopting vertical and horizontal integration.

Souza (2007) elaborated a synthesis (Table 1) that shows the advantages and disadvantages of vertical integration as a result of the presence of high transaction costs.

Table 1

Advantages and Disadvantages of the Vertical Integration strategy

Advantages of Vertical Integration	Disadvantages of Vertical Integration
• Ensure savings in combined operations; information; coordination and internal control; • Avoiding the market • Ensure supply and/or demand • Eliminate bargaining • Increase barriers to entry and mobility • Enter a high-return business • Defend against market closure • Facilitate adaptation in sequential decision-making • Mitigating opportunism • Promote convergent expectations (reduce uncertainties) • Dominate and promote information gain • Achieve an atmosphere of greater satisfaction • Rationalize inventory levels • Savings in operations arising from technological interdependence; elimination of risk premium; reduced transaction costs; economies of scale; stable relationships and resource retrieval; • Achieve product and price differentiation	• Costs of Going Through Mobility Barriers • Increased operating leverage • Reduced flexibility to change partners • High global exit barriers • Need for capital investments • Closing access to the market research provider or know-how • Need to provide incentives • Different administrative needs • Predisposition to favor maintenance or extension of internal operations • Distortion in communication • Internal opportunism • Bounded rationality • Adding bureaucracy • Loss of moral engagement • Capital imbalance • Reduced flexibility • Loss of specialization • Lack of savings with unbalanced stages of integrated operations; Administration and lower returns • Increased operating leverage

Source: Adapted from Souza (2007)

3.2 BENEFITS OF VERTICAL INTEGRATION IN THE APPLICATION OF AGROCHEMICALS

3.2.1 The Pesticide "Concessionaire" Model: A Proposal for Technical and Safe Application

At the heart of this proposal is the formation of a network of service and application centers, managed or supervised directly by the agrochemical producing companies. responsible for the entire product cycle in the process: from the technical recommendation, based on precise diagnoses, through the application carried out by highly trained and certified teams, to the post-application follow-up and the proper disposal of the packaging. structure goes beyond a simple logistical change; It is, in fact, an essential restructuring of responsibilities and incentives, harmonizing the interests of the manufacturer with those of the producer and, consequently, of society.

3.2.2 Guarantee of Technicality in Application and Optimization of Resources

The main highlight of this model is the increase in the technical level of the applications. Currently, the lack of technical knowledge among several rural productions, combined with the lack of assistance, results in inadequate applications and improper use of equipment (SILVA; OLIVEIRA, 2020). In this new model of vertical integration, the application teams would be composed of specialists: agricultural technicians, agricultural technicians and machine operators trained and constantly updated with the latest practices and technologies available. We consider protective equipment, such as GPS sprays, drones, and remote sensing systems, which act in constant permanence and real-time weather monitoring, all with the aim of reducing drift and avoiding contamination of adjacent areas (EMBRAPA, 2022).

Manufacturers, who have the most in-depth knowledge about their products, will establish standardized usage protocols to ensure maximum efficacy and minimize negative effects. In addition, a systematic collection of data on application and performance in the field would generate a virtuous cycle of learning and constant improvement. With the big data generated, it would be feasible to adjust dosages, improve recommendation algorithms, and consider success or failure patterns, converting the use of agrochemicals into an authentic science of applied data (CHEN et al., 2021).

The producer would not only maximize their investment, but also have a rationalization in the use of inputs – a double benefit for the economy and the environment. Consider the practical benefits: reduced machine passes result in less fuel consumption, less soil compaction, and more time for the producer to focus on strategic decisions for his property (SANTOS; PEREIRA, 2023).

3.2.3 Resistance Management and Product Longevity: An Economic Sustainability Perspective

The application made with the proper technique and proper use without the risk of accelerated development of resistance in pests, diseases and weeds (NEVES et al., 2018; SHAW; LEWANDOWSKI, 2019). Insufficient doses or applications at the wrong times end up selecting the most resistant individuals, which, over time, makes agrochemicals ineffective. This forces them to look for new molecules, a very expensive and time-consuming process, with diminishing returns (GAO et al., 2020). The loss of effectiveness of an agrochemical, due to resistance, not only causes direct losses to the producer – who needs to resort to more expensive or less efficient alternatives – but also represents a significant loss of intellectual and financial capital for the industry that developed it.

In the proposed model, the strict control of the application, added to a constant monitoring of the effectiveness in the field, would allow the implementation of much more effective and proactive resistance management strategies. Manufacturers have a direct interest in extending the life of their products. This would encourage it to promote the distribution of active ingredients, the use of mixtures, and the application only when necessary, following the principles of Integrated Pest Management (IPM) (MAPA, 2021). This alignment of interests between the manufacturer and agronomic sustainability is a critical differentiator.

Instead of focusing only on the sale, the manufacturer would focus on the solution and the longevity of the effectiveness. This translates into lower selection pressure, greater sustainability of the available chemical arsenal, and ultimately less need for heavy R&D investments for new molecules, benefiting the industry in the long run. The ability to obtain data on efficacy in different regions and crops would allow manufacturers to adjust their recommendations and develop customized resistance management programs, strengthening the resilience of agricultural systems (FERREIRA; GOMES, 2022).

3.2.4 Impact on Public and Occupational Health: From Exposure to Active Prevention

The use of agrochemicals by specialized teams, under the direct supervision of manufacturers, would result in a significant change in public and occupational health. The focus shifted from harm mitigation to proactive prevention. Applicators received constant and rigorous training on the proper use of state-of-the-art Personal Protective Equipment (PPE), safety procedures, related to concentrated products (including external transfer systems) and first aid. The direct responsibility of the manufacturer in promoting full adherence to occupational safety standards, the implementation of occupational health programs, and the continuous monitoring of employee health, considerably avoiding cases of acute and chronic poisoning among rural workers (FIOCRUZ, 2019; PEREIRA et al., 2022).

The standardization of processes and rigorous internal inspection would be key elements to ensure the safety of operators, who would become highly qualified and valued professionals.

The standardization of procedures and strict internal supervision will be fundamental to ensure the safety of operators, highly competent and recognized and valued professionals. A more technical application would lead to a reduction in agrochemical residues in food for the final consumer. The precise application of chemical substances, strictly respecting the withdrawal periods and recommended doses, reducing exposure to these substances. The full traceability of the application, ensured by the "concessionaire" and digitally registered, would enable a more efficient control of the quality of food "from the door to the inside". This would

increase consumer confidence in food safety and make it easier to identify potential problems (ANVISA, 2023).

This strict control would help certify products with less environmental and health impact, adding value and highlighting Brazilian production in the global market, especially in export markets with high sanitary standards. Transparency in the production chain, made possible by this model, could become a competitive factor for Brazilian agribusiness, responding to the growing demand for safe food and production in a sustainable way (UN, 2021).

3.2.5 Environmental Benefits and Ecological Sustainability

An optimized application of agrochemicals, with an emphasis on precision, and the reduction of losses, would result in considerably lower environmental impacts. A reduction in the contamination of soils, water resources (both surface and dense) and adjacent ecosystems would represent a direct and easily measured benefit (RODRIGUES; ALVES, 2021).

The reduction of the total amount of agrochemicals applied, maintaining effectiveness, helping to preserve biodiversity and fundamental ecosystem services, such as pollination and natural biological control. In addition, the centralized and professional management of the disposal of empty packaging and leftover products, under the responsibility of the manufacturer, would reinforce reverse logistics and considerably reduce environmental contamination by hazardous waste (IBAMA, 2020).

The search for greater efficiency and lower environmental impact would be perfectly in tune with the growing sustainability standards of modern agriculture and with the global sustainable development goals. This model has the capacity to place Brazil at the forefront of sustainable agricultural practices, not only by implementing new technologies, but also by a systemic restructuring that incorporates the negative externalities associated with the use of agrochemicals, fostering cleaner food production and a healthier rural environment. The reduction of the carbon footprint related to agricultural production, obtained through the optimization of the use of inputs and reduction in the demand for new cultivation areas due to higher productivity per hectare, would also represent a very positive result (IPCC, 2022).

3.2.6 Challenges, Implications and Perspectives for Implementation

While it brings clear benefits, adopting this model would not be free from complex and varied challenges, which required detailed analysis and well-designed mitigation strategies.

- **Economic Feasibility and Business Structuring:** Market restructuring would require manufacturers to make a significant initial investment in building the entire infrastructure

of the "dealerships" (service centers, equipment, vehicles) and training personnel. The main question is: how would this cost be transferred and what would be the pricing model for the farmer? Would there be a cost for use? A tariff per hectare? Or maybe a subscription model that encompasses the product and the service? The attractiveness for the farmer will depend on the perception of added value in relation to the direct cost, considering aspects such as higher productivity, lower risk, regulatory compliance, time and labor savings for the farmer will depend on the perception of added value in relation to the direct cost, considering aspects such as higher productivity, lower risk, regulatory compliance, time and labor savings. For small producers, government subsidies, special credit lines or cooperative models can be essential to guarantee access to technology and avoid exclusion, ensuring that benefits are distributed equitably (COSTA; LIMA, 2023).

- **Regulation and Competition:** It would be important to develop a robust regulatory framework that encourages fair competition, ensures transparency in pricing and services, and avoids monopolistic or oligopolistic practices. The creation of specific regulatory agencies or the adaptation of existing ones (such as CADE and consumer protection agencies) would be essential to monitor this new market, protecting the interests of producers and society (CADE, 2024). A clear definition of legal responsibilities in case of application failures or environmental damage would also be essential.
- **Acceptance and Autonomy of the Rural Producer:** The acceptance by rural producers, who would have to adapt to a new way of acquiring and applying agrochemicals, is a critical factor. Many farmers value autonomy in their management decisions and may initially resist the idea of outsourcing such an important step in their production process. The transition would require a significant effort of communication, demonstration of concrete results (increased productivity, long-term cost reduction, greater security) and, above all, the building of trust. Flexible models, which allow different levels of producer involvement – perhaps with assisted self-management options or specialized consulting – could facilitate the transition, respecting the farmer's culture and experience (EMATER, 2020).
- **Logistics and Infrastructure:** Brazil, with its continental dimensions and vast agricultural area, often in remote regions and with precarious infrastructure, presents an immense logistical challenge. The creation of a network of "concessionaires" with sufficient capillarity to serve all producers would require robust logistics planning and

massive investment in transportation, storage and communication infrastructure. Digitalization and connectivity would be essential to manage this network efficiently, allowing for service scheduling, remote monitoring, and real-time data collection. Public-private partnerships could be explored to enable the expansion of infrastructure in hard-to-reach areas (CNT, 2023).

- **Social Aspects and Equity:** It is essential to ensure that this model does not accentuate the inequalities that already exist in the countryside. Smallholder farmers and traditional communities, which often already face limited access to technologies and technical assistance, cannot be marginalized. Public policies of inclusion, differentiated financing programs and the adaptation of the model to meet these realities would be imperative. The formation of producer cooperatives to access the services of the "concessionaires" or the creation of itinerant service models could be solutions to ensure that no producer is excluded (MDA, 2022). The training of local labor to work in the "concessionaires" would also generate jobs and regional development.

However, the gains in safety, efficiency and sustainability are so significant that they justify in-depth exploration of this topic. Overcoming these challenges will require constructive dialogue and strategic collaboration between the government, the agrochemical industry, rural producers, academia and civil society. The transition to a more responsible system of agrochemical use is not just a technical issue, but a social and environmental demand that requires an innovative vision and the courage to redefine paradigms.

4 CONCLUSION

This study proposed and debated an innovative model for the application of agrochemicals in Brazil, based on the vertical integration of manufacturers. These manufacturers would become directly responsible for the application service in the field, similar to the model of dealership deliveries. The results suggest that this strategy can transform the risk management linked to these inputs, fostering a safer, more effective and sustainable agriculture.

The creation of agrochemical "concessionaires", managed by specialized technical teams and under the direct supervision of manufacturers, is proposed as a multifaceted solution. It is expected that this encourages the model of technicality in the application, leading to a more efficient control of the resistance of sentences and diseases and increasing the durability of the products.

This model is expected to promote technicality in application, resulting in more effective management of pest and disease resistance, extending the shelf life of products and optimizing resources.

In addition, a significant improvement in the occupational health of those applied is expected through specific training and proper use of PPE, as well as in the food safety of the final consumer, due to the reduction of residues in food and increased traceability. The environmental benefits, resulting from precise application and responsible disposal, are important, helping to preserve biodiversity and natural resources.

Although challenges related to investments, regulation, competition, accessible by rural producers, logistics and heritage need to be approached with caution, the idea of vertical integration in the use of agrochemicals indicates a promising path for safer, more effective and sustainable agriculture in Brazil.

It is recommended that future research investments in in-depth economic forecast studies for various scales of production, governance models for governance as "concessionaires" that ensure competition and producer protection, in addition to the regulatory impact necessary for the transition to this new paradigm. For Brazil to become an example in sustainable agricultural practices, it is essential that government, industry, the productive sector and civil society work together to transform this vision into a reality that benefits everyone.

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TRANSITION FROM INSTITUTIONAL PARADIGMS TO SUSTAINABILITY: A BIBLIOMETRIC REVIEW OF SCIENTIFIC PRODUCTION

TRANSIÇÃO DE PARADIGMAS INSTITUCIONAIS PARA A SUSTENTABILIDADE: UMA REVISÃO BIBLIOMÉTRICA DA PRODUÇÃO CIENTÍFICA

TRANSICIÓN DE PARADIGMAS INSTITUCIONALES A LA SOSTENIBILIDAD: UNA REVISIÓN BIBLIOMÉTRICA DE LA PRODUCCIÓN CIENTÍFICA



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ABSTRACT

This research aims to conduct a bibliometric mapping of institutional change related to sustainability. To this end, a search was carried out in the Scopus, SciELO, and Web of Science databases using the keywords "institutional change and energy and environmental science." The search was limited to scientific journals from the last five years. The objective

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was to perform a bibliometric mapping on the topic of institutional change and sustainability, and to analyze the performance of the bibliometric results, considering several aspects. The method used in the research was descriptive, which aims to transcribe, describe, interpret, and explain the results obtained with the aid of bibliometric analysis. This aims to identify and analyze the profile of scientific production on a given topic, using a quantitative approach through descriptive statistics. From the point of view of bibliometric networks, it was observed, through the mapping of keywords, that the researched topic is inserted in different contexts, separated into three aspects: 1 – institutional change, 2 – institutional structure, and 3 – sustainability. All the selected articles point to institutional change as one of the mitigating actions in relation to sustainable development. This change involves the restructuring of institutions. The process is slow and gradual because there are resistance mechanisms, mainly from the economic sector, but also partly from the academic sector. Researchers argue that the Sustainable Development Goals (SDGs) have a limited and inadequate conceptualization, which hinders their practical application. Although they aim to promote sustainable patterns, the SDGs fail to provide clear targets and effective guidance for the necessary institutional changes. The authors report that a holistic view of the challenges is important and describe the blockchain-based micro-network model, proposing changes in institutions as well as in the scientific and academic environment.

Keywords: Institutional Change. Sustainability. Bibliometrics.

RESUMO

Esta pesquisa tem como objetivo realizar um mapeamento bibliométrico a respeito da mudança institucional relacionada à sustentabilidade. Para isso, foi realizada uma pesquisa nas bases de dados Scopus, Scielo e Web of Science, usando a palavra-chave “institutional change and energy and environmental science”. A pesquisa foi delimitada considerando apenas os periódicos científicos de 2018 a 2022. O objetivo foi analisar o desempenho dos resultados bibliométricos, considerando alguns aspectos. O método utilizado na pesquisa foi o descritivo, que objetiva transcrever, descrever, interpretar e explicar os resultados obtidos com o auxílio da análise bibliométrica. Esta visa identificar e analisar o perfil da produção científica de um determinado tema, fazendo-se uso da abordagem quantitativa através da estatística descritiva. Do ponto de vista das redes bibliométricas, observou-se, por meio do mapeamento das palavras-chave, que o tema pesquisado está inserido em diferentes contextos, separados em três vertentes: 1 – mudança institucional, 2 – estrutura institucional e 3 - sustentabilidade. Todos os artigos selecionados apontam a mudança institucional como uma das ações mitigadores em relação ao desenvolvimento sustentável. Essa mudança passa pela reestruturação das instituições. O processo é lento e gradual, porque existem mecanismos de resistência principalmente por parte do setor econômico, mas também em parte do setor acadêmico. Pesquisadores argumentam que os Objetivos de Desenvolvimento Sustentável (ODS) possuem uma conceituação limitada e inadequada, o que prejudica sua aplicação prática. Embora busquem promover padrões sustentáveis, os ODS falham em oferecer metas claras e orientações eficazes para as mudanças institucionais necessárias. Os autores relatam que é importante uma visão holística dos desafios e descrevem o modelo das micro redes baseado em blockchain, propondo mudanças nas instituições assim como no meio científico e acadêmico.

Palavras-chave: Mudança Institucional. Sustentabilidade. Bibliometria.

RESUMEN

Esta investigación tiene como objetivo realizar un mapeo bibliométrico del cambio institucional relacionado con la sostenibilidad. Para ello, se realizó una búsqueda en las bases de datos Scopus, SciELO y Web of Science, utilizando la palabra clave "cambio institucional y energía y ciencia ambiental". La búsqueda se limitó a revistas científicas publicadas entre 2018 y 2022. El objetivo fue analizar el desempeño de los resultados bibliométricos, considerando diversos aspectos. El método empleado fue descriptivo, con el fin de transcribir, describir, interpretar y explicar los resultados obtenidos mediante el análisis bibliométrico. Esto busca identificar y analizar el perfil de la producción científica sobre un tema determinado, utilizando un enfoque cuantitativo a través de la estadística descriptiva. Desde la perspectiva de las redes bibliométricas, se observó, mediante el mapeo de palabras clave, que el tema investigado se inserta en diferentes contextos, divididos en tres aspectos: 1) cambio institucional, 2) estructura institucional y 3) sostenibilidad. Todos los artículos seleccionados señalan el cambio institucional como una de las acciones de mitigación en relación con el desarrollo sostenible. Este cambio implica la reestructuración de las instituciones. El proceso es lento y gradual debido a la existencia de mecanismos de resistencia, principalmente del sector económico, pero también, en parte, del sector académico. Los investigadores sostienen que los Objetivos de Desarrollo Sostenible (ODS) presentan una conceptualización limitada e inadecuada, lo que dificulta su aplicación práctica. Si bien buscan promover estándares sostenibles, los ODS no ofrecen metas claras ni una guía eficaz para los cambios institucionales necesarios. Los autores señalan la importancia de una visión holística de los desafíos y describen el modelo de microred basado en blockchain, proponiendo cambios tanto en las instituciones como en el entorno científico y académico.

Palabras clave: Cambio Institucional. Sostenibilidad. Bibliometría.

1 INTRODUCTION

In 2015, the United Nations established the Sustainable Development Goals (SDGs), creating a political guide to address global socio-environmental crises. The so-called 2030 Agenda focuses on the urgent transformation of consumption and production patterns, especially in the face of a world population that is moving towards eight billion people and demands more sustainable urban solutions. However, the implementation of these changes is hampered by the rigidity of bureaucratic systems, which are not yet accustomed to adaptive and flexible management models in the face of climate variations.

A central point of sustainability is the diversification of the energy matrix. Historically based on large hydroelectric plants and biomass, renewable energy now needs to explore untapped potential and adopt alternative sources. For this transition to occur in a practical way, it is essential to have specific government regulations and incentives, responding to the exhaustion of models based on non-renewable sources.

To understand how these transformations occur, sources define institutions as enduring norms, rules, and procedures that shape social and political behavior. Some key features of these structures are:

- **Stability:** Generally, institutions do not change instantaneously; their evolution is usually **slow and gradual**.
- **Interconnection:** Changes in an institution often have repercussions on other entities and public policies.
- **Rules of the Game:** They work as the guide for the actions of individuals and organizations, and can be formal or informal.

Institutional change can be triggered by internal or external shocks. From the perspective of historical institutionalism, the "critical junctures" stand out, which are gaps in periods of crisis that allow for a lasting change in the trajectory of a policy or institution.

The article in question seeks to map the profile of scientific production on this topic in the Web of Science, Scopus and Scielo databases. The focus is to analyze how new norms and regulatory procedures are restructuring the sustainability paradigm and how the behavior of social groups can influence or even create new institutions.

2 METHODOLOGY

The method used in the research was descriptive, which aims to transcribe, describe, interpret and explain the results obtained with the help of bibliometric analysis. This aims to

identify and analyze the profile of the scientific production of a given topic, making use of the quantitative approach through descriptive statistics.

The databases used were the Web of Science, Scielo and Scopus, which are available on the journal portal Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). These databases have databases of abstracts and citations of peer-reviewed literature, including scientific journals, books, and conference proceedings, which cover topics from various areas of knowledge.

The search was carried out on 03/09/2026, covering the period from 2018 to the year 2023. This period was defined, due to the greater availability of open articles. The terms used were searched in the title, abstract, and keywords of the articles. The search was restricted to articles from open journals. The syntax of the databases was as follows: "institutional change and energy and environmental science". The main search was through the keyword "institutional change", restricting the search to the keywords: energy and environmental science".

The data related to these documents (journals, authors, references, citations, etc.) were stored in a text file for performance analysis and bibliometric mapping. The descriptive analysis and mapping were performed by the Bibliometrix software, which is part of RStudio, which is the most popular integrated development environment (IDE) for the R programming language, being widely used in data science, statistics and academic research.

The method of analysis of the empirical objects will follow three main phases organized as follows:

Preparatory phase: Cut out the theme and keyword for the research (institutional change and energy and environmental science); Search in databases (web of Science and Scopus); Export the data to the Bibliometrix application in RStudio; Generate the quantitative data tables and graphs in Bibliometrix.

Analytical phase: Review of the literature on the subject; Grouping of quantitative data in tables and graphs generated in Bibliometrix; Bibliometric analysis.

Descriptive phase: Interpretation of the results found in the Bibliometrix.

3 BIBLIOMETRIC ANALYSIS

The objective of this section is to analyze the performance of bibliometric results, considering some aspects, such as the annual scientific production, the evolution of citations, relevant sources and authors, world scientific production and the bibliometric networks that most collaborate with each other in scientific productions on the theme transition of institutional

paradigms and sustainability. Table 1 shows the main data on this survey in the period from 2018 to 2023. 298 documents were found in the databases (web of Science, scielo and scopus) with 1030 authors involved and 20,986 references.

Table 1

Summary of the survey data

Key information about the survey data	
Description	Results
Time Range	2018/2023
Sources (newspapers, books, etc.)	129
Documents	298
Annual growth rate (%)	-36,9
Average document age	2,83
Average citations per document	12,54
References	20986
Authors	1030
Most used keywords (ID)	1346
Keywords by author (DE)	1130

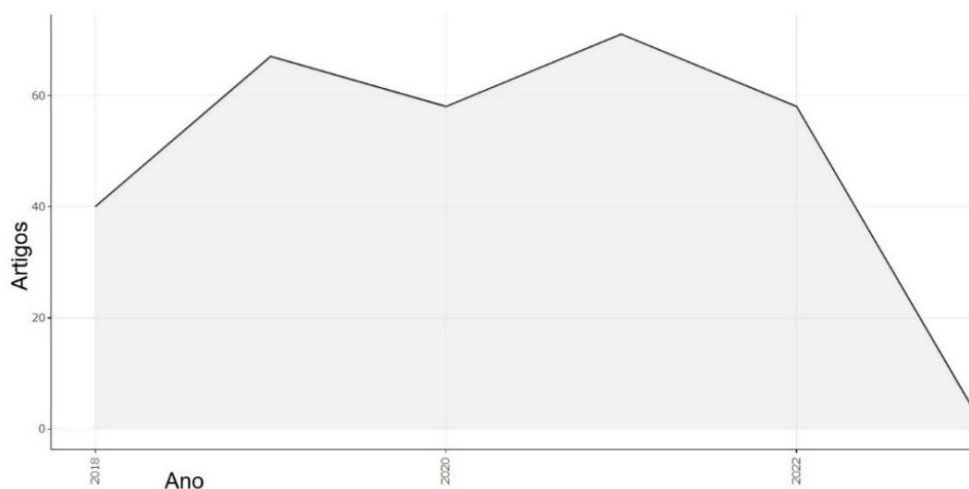
Source: Web of Science search result, Scopus, Scielo, obtained from Bibliometrix (2023)

4 ANNUAL SCIENTIFIC PRODUCTION

Figure 1 shows the evolution of the number of publications from 2018 to 2023 on the topic of transition of institutional paradigms and sustainability. It can be identified that in 2018 there are 40 articles published, with a noticeable increase in 2019 to 70 articles, almost doubling compared to the previous year. Until 2022, the situation of the average number of publications remains unchanged, but in 2023, due to being still at the beginning, the number of publications was not so expressive.

Figure 1

Annual scientific production

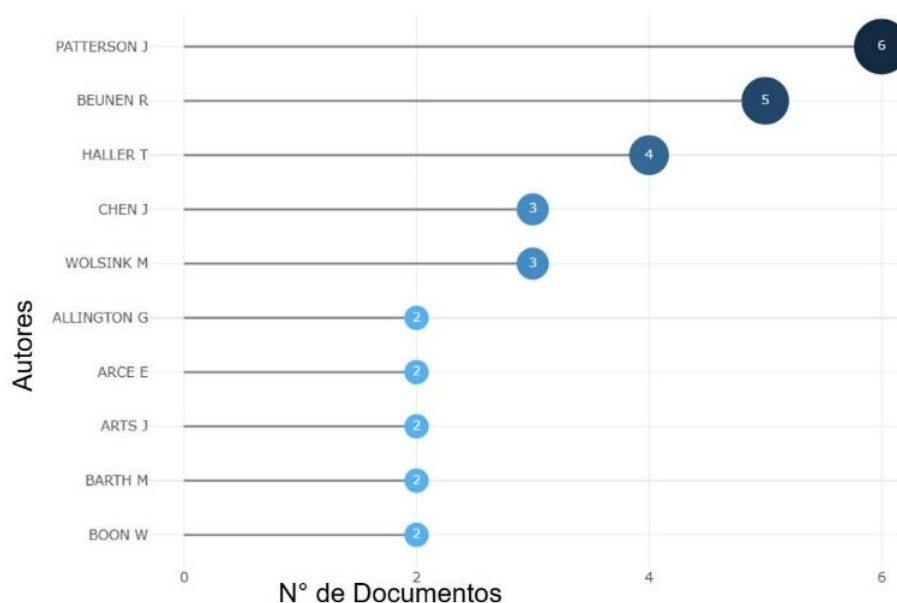


Source: Web of Science search result, Scopus, Scielo, obtained from Bibliometrix (2023)

5 MOST RELEVANT AUTHORS

Figure 2

Most relevant authors

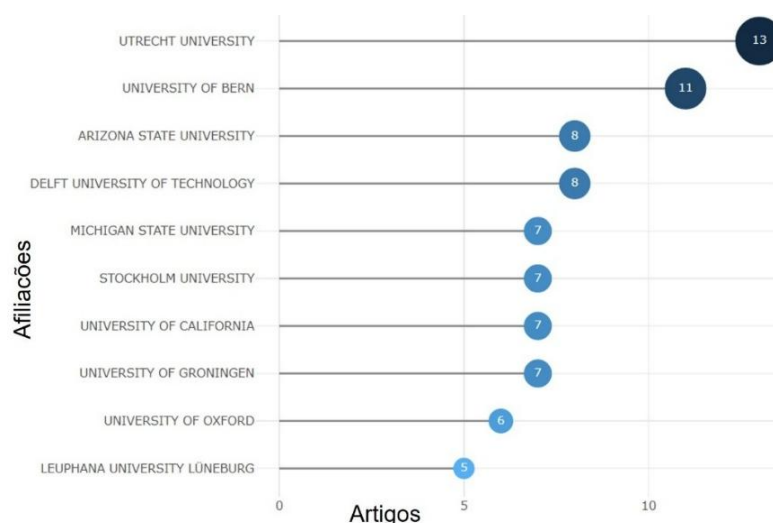


Source: Web of Science search result, Scopus, Scielo, obtained from Bibliometrix (2023)

The ten authors, who published the most on the theme of institutional change and renewable energy, can be seen in figure 2. Patterson is the most relevant with six publications. In second place, the author Beunen (2019) with 5 articles. In third place was the researcher Haller with 4 publications. Chen and Wolsink (2018) were in fourth position in publications, both with 3 articles. The others with two publications each completed the list with 2 articles each.

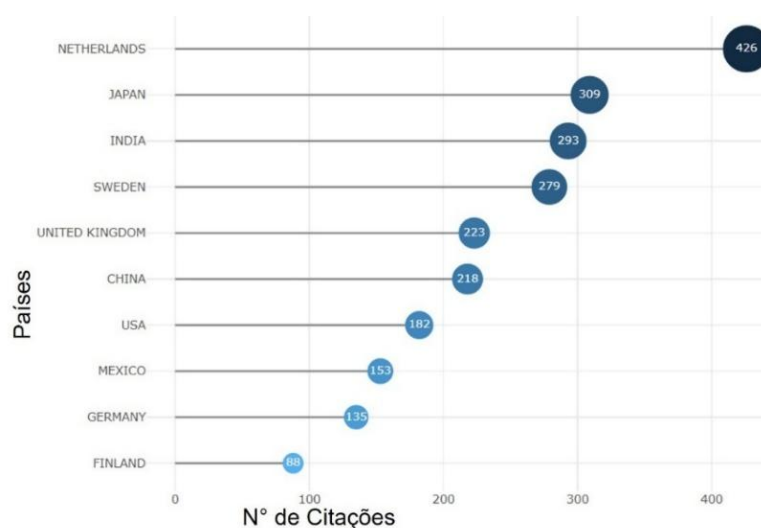
6 MOST RELEVANT AFFILIATIONS

Figure 3 shows the ten most relevant affiliations on the topic in question. Utrecht University was the most relevant with 13 articles, the University of Bern in second place with 11 publications. In third place were the universities Arizona State University and the Delft University of Technology, both with 8 publications. In fourth place with 7 articles each were the following universities: Michigan State University, Stockholm University, University of California and the University of Groningen. In fifth place was the University of Oxford, which published 6 articles. Finally, in sixth place we had Leuphana University Luneburg with 5 publications.

Figure 3*Most relevant affiliations*

Source: Web of Science search result, Scopus, Scielo, obtained from Bibliometrix (2023)

7 SCIENTIFIC PRODUCTION OF COUNTRIES

Figure 4*Most cited countries*

Source: Web of Science search result, Scopus, Scielo, obtained from Bibliometrix (2023)

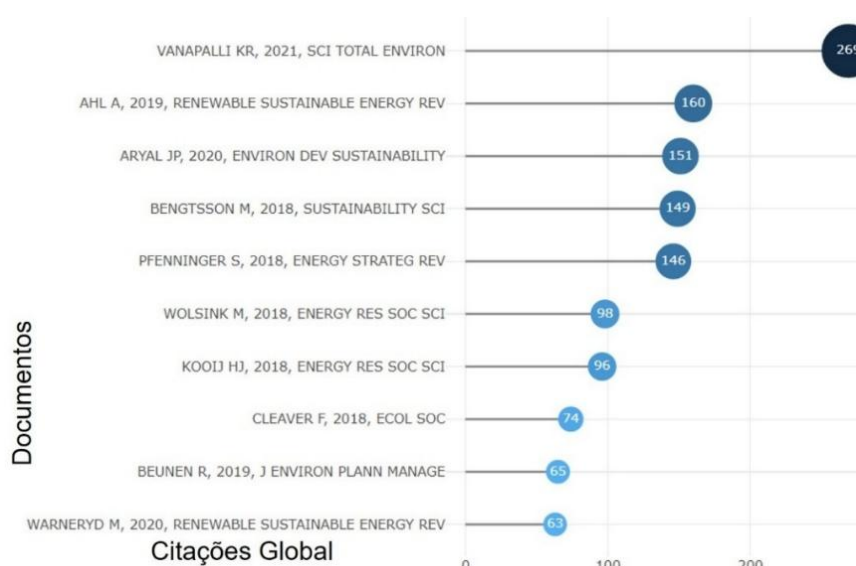
Figure 4 shows the situation of scientific production in the countries in relation to the authors who published on the subject. It is noted that there is a progressive increase, showing that the USA, the Netherlands and the United Kingdom have been standing out, closely followed by China and Germany. It is observed that the number of citations and correspondences confirm what was previously said, that is, the Netherlands with 426 citations, Japan with 309 citations and India 293, demonstrate the predominance in the scientific production on the subject studied

of the European countries, the USA and Asia, represented by Japan and China. Countries like Brazil still participate with a small scientific production, compared to the others.

8 MOST CITED DOCUMENTS GLOBALLY

Figure 5

Most cited documents globally



Source: Result of the Web of Science, Scopus, Scielo search, at Bibliometrix (2023)

Figure 5 shows the most cited documents globally. The article *Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic* published by Vanapalli and other authors (2021) in the journal *Science of The Total Environment*, this was the most cited document with 209 citations. In second place is the publication: *Review of blockchain-based distributed energy: Implications for institutional development*, published by researcher Amanda Ahl together with other researchers (2017) with 160 citations, in the journal *Renewable and Sustainable Energy Reviews*. The article *Climate change and agriculture in South Asia: adaptation options in smallholder production systems* occupies the third position, participating with 151 citations. The research of the author Arial developed together with other researchers in the year 2020. The other documents participated with an average of approximately 100 citations.

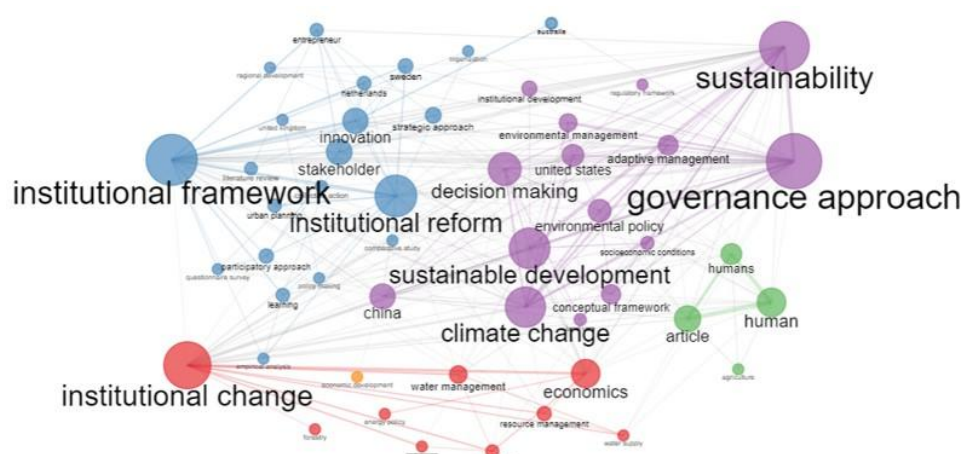
9 BIBLIOMETRIC NETWORKS

Figure 6 shows the network of co-occurrence of the keywords; in it, the following are observed: the most frequent terms, with the occurrences proportional to the size of the circles and label; the associations between the words, given by the links and proximity; the groups,

indicated by the colors. In this network, four groups were formed, three of which stood out the most: the red cluster, representing the occurrence of the terms *institutional change* and *economics*. The cluster represented by the color blue identified the highlighted terms *institutional framework* and *institutional reform*. The lilac cluster stood out with the keywords *governance approach* and *sustainability*. It was observed that, although each group has a specific theme, these groups do not distance themselves much because the themes are very close and the interconnections occur more frequently.

Figure 6

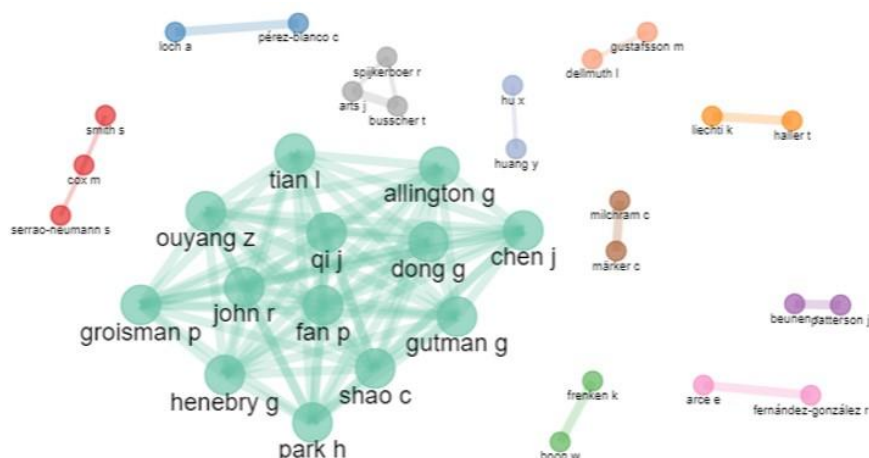
Co-occurrence networks



Source: Web of Science search result, Scopus, Scielo, obtained from Bibliometrix (2023)

Figure 7

Collaboration networks by author



Source: Web of Science search result, Scopus, Scielo, obtained from Bibliometrix (2023)

Figure 7 shows the collaboration network between the researchers, forming 11 small groups represented by circles of different colors. The collaboration network represented by the color green is the one that stood out the most, both in terms of the number of members, with

the size of the circles increased, and in the quantity, in relation to the other groups. It is noteworthy that the collaboration groups do not connect with each other. This means that collaboration networks can grow even more if connections and integration increase.

10 CONTENT ANALYSIS OF THE FIVE MOST RELEVANT PUBLICATIONS

In this topic, the content of the abstracts of the five most relevant articles found in this bibliometric review was analyzed, and most of the findings identified a strong tendency to use sustainability to enhance the process of institutional change. In the samples examined, it was observed that the researchers used the bibliographic references produced over time, as well as empirical and statistical studies to support their research, which contributed to increase the confidence and security of the results presented. In these terms, with the purpose of verifying which articles published in journals aroused the interest of researchers, this research includes the five most cited articles, with their respective titles and DOI, which showed that sustainability and environmental issues are beneficial to the field related to the transition of institutional paradigms as a whole.

The first article *Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic*, studies conducted by Vanapalli & Al. (2021), the researchers published on the increased complexity of plastic waste management during the COVID-19 pandemic, due to numerous aspects, either because demand has increased or because of the maintenance of hygienic care. The article demonstrates the inadequacies and inefficiencies of our current waste management system in addressing this problem, further increasing dependence on plastic and exacerbating environmental problems. Therefore, the suggestion of the research is to reduce pollution with waste management, prioritizing policies, changing social and individual behaviors through government and corporate action.

Ahl & Al. (2019) published the second article, called *Review of blockchain-based distributed energy: Implications for institutional development*, where they recognize the complexity of the energy situation, in which the distribution of its sources is essential. The aim of the paper is to holistically explore the potential challenges of blockchain-based microgrids and propose implications for the institutions involved, as well as the academic world. In this sense, the research is distributed according to the following analytical structure: 1) Technological, 2) Economic, 3) Social, 4) Environmental and 5) Institutional dimensions. Hence, gradual institutional changes that leverage regulatory and community-building sandbox approaches are proposed as potential avenues to incorporate this multidimensionality.

Aryal and Al. (2020) present in their publication *Climate change and agriculture in South Asia: adaptation options in smallholder production systems*, in the journal *Environment, Development and Sustainability*, a systematic review of the impacts of climate change on agricultural production and the main options in this sector, making them available and adapting to such changes. The research concluded that agricultural practices exist and are helping to adapt to climate change, however, the institutional configuration has not been sufficiently mature for the implementation and dissemination of technical solutions. The researchers say it is important to examine how to implement the necessary institutional change, as well as to encourage the generation of investment funds in these changes and to design policies to adapt to climate change in the long term, rather than focusing only on the technological aspect.

In the fourth article discussed, *Transforming systems of consumption and production for achieving the sustainable development goals: moving beyond efficiency*, Bengtsson & Al. (2018) analyzed the Sustainable Development Goals (SDGs), which aim to ensure sustainable consumption and production patterns. The researchers maintain that, although these goals were developed in 2015 and the scientific evidence and importance of the theme, the SDGs do not establish very clear goals or efficient guidelines regarding the operationalization of institutional changes to this agenda. They conclude that the SDGs offer a partial and inadequate conceptualization, making it difficult to implement the goals. As such, the survey offers not only analytical results, but also suggestions on how governments and other stakeholders could effectively pursue Sustainable Consumption Patterns (HCPs).

Pfenninger & Al. (2018) published in the *journal Energy Strategy Reviews* the article *Opening the black box of energy modelling: Strategies and lessons learned* about the great transition in the global energy system, in government and academic planning and decision-making. The researchers give importance to transparency and the open availability of energy models and data to the detriment of current models, which are closed. The research proposes a practical how-to guide based on the collective experience of the members of the *Open Energy Modelling Initiative (Openmod)*.

11 CONCLUSIONS

The objective of this study was to carry out a bibliometric mapping on the theme of transition of institutional paradigms and sustainability. It was observed that there are already a reasonable number of studies that study this theme, but the scientific production still shows evolutionary progress. This shows the importance of co-evolution of economic variables on the

one hand and conventional or state planning and, on the other, those of institutional change to establish a virtuous circle of development.

From the point of view of bibliometric networks, it was observed, through the mapping of keywords, that the researched theme is inserted in different contexts, separated into three strands: 1 – *institutional change*, 2 – *institutional structure* and 3 – *sustainability*.

All selected articles point to institutional change as one of the mitigating actions in relation to sustainable development. This change involves the restructuring of institutions. According to Ahl & Al. (2019), the process is slow and gradual, because there are resistance mechanisms mainly on the part of the economic sector, but also on the part of the academic sector. The authors report that a holistic view of the challenges is important and describe the blockchain-based microgrid model, proposing changes in institutions as well as in the scientific and academic environment. Another example of a model is the one proposed by researchers Cleaver & Whaley (2018), who defend adaptive governance, in which it has gained space in academic and political circles. Warneryd (2020), in his research on community microgrids, reports that formal institutions influence informal institutions, although their objectives are different.

Researchers who have examined the Sustainable Development Goals (SDGs) — focused on ensuring sustainable production and consumption patterns — point to critical flaws in their framework. According to the study, despite the relevance of the theme and the scientific basis available since 2015, the SDGs lack clear and effective guidelines to transform institutions in practice. The conclusion is that the conceptual definition of these objectives is limited and insufficient, which creates real obstacles for the goals to be successfully achieved.

Beunen & Patterson (2019) argue that there is a critical need to pay attention to the fundamentally political character of institutional work, the cumulative effects of action carried out by multiple actors, and the communicative and discursive dimensions. These researchers argue that the concept of institutional work opens up new possibilities to unravel the long-standing challenge of understanding institutional change in environmental governance.

In general, it can be said that the more developed countries are more articulated or are more visible with the institutional change linked to the environmental aspect. This is justified because publications with scientific impact are located in these countries. In countries such as Brazil, it is also expressed in the three strands mentioned above, in which the *co-occurrences* of networks on the themes and the most relevant affiliations between universities were identified, but the impact of the publications occurs in a localized way, not reaching international journals.

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MACROCIRCULAR GRAVITATIONAL MOTION THEORY
TEORIA DO MOVIMENTO GRAVITACIONAL MACROCIRCULAR
TEORÍA DEL MOVIMIENTO GRAVITACIONAL MACROCIRCULAR



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ABSTRACT

Based on the concepts of dark matter and dark energy, I present a hypothesis that all the universal energy that organizes and sustains the cosmos is manifested in macrocircular gravitational motion, as a driving force behind the movements of galaxies, which do not represent an expansive linear motion, but rather the macrocircular motion of the gravitational center. The gravitational center energy, therefore, is the organizing principle that maintains the cohesion and structure of the universe, exerting a powerful influence on everything that exists through macrocircular motion. Not necessarily in a perfect circle, but in a centrally attractive pattern. It is concluded that macrocircular gravitational motion reveals itself in a universal dynamic of circuits and patterns that we observe at all levels of reality, from stellar, planetary, and satellite orbits to the movements of subatomic particles.

Keywords: Dark Matter. Dark Energy. Universal Energy. Cosmos. Macrocircular Gravitational Motion. Driving Force. Organizing Principle. Centrally Attractive Pattern. Universal Dynamics.

RESUMO

Tomando por base os conceitos de matéria e energia escuras apresento uma hipótese de que toda a energia universal que organiza e sustenta o cosmos é manifestada no movimento gravitacional macrocircular, como uma força motriz por trás dos movimentos das galáxias, que não representam um movimento linear expansivo, mas o movimento macrocircular centro gravitacional. A energia centro gravitacional, portanto, é o princípio organizador que mantém a coesão e a estrutura do universo, exercendo uma influência poderosa sobre tudo o que existe por meio do movimento macrocircular. Não necessariamente em círculo perfeito, mas no padrão centralizadamente atrativo. Conclui-se que o movimento gravitacional macrocircular revela-se numa dinâmica universal de circuito e padrões que observamos em todos os níveis da realidade, desde as órbitas estelares, planetárias, satelitais até os movimentos das partículas subatômicas.

Palavras-chave: Matéria Escura. Energia Escura. Energia Universal. Cosmos. Movimento Gravitacional Macrocircular. Força Motriz. Princípio Organizador. Padrão Centralizadamente Atrativo. Dinâmica Universal.

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RESUMEN

Basándome en los conceptos de materia oscura y energía oscura, presento la hipótesis de que toda la energía universal que organiza y sustenta el cosmos se manifiesta en un movimiento gravitacional macrocircular, como fuerza impulsora de los movimientos de las galaxias, los cuales no representan un movimiento lineal expansivo, sino el movimiento macrocircular del centro gravitacional. La energía del centro gravitacional, por lo tanto, es el principio organizador que mantiene la cohesión y la estructura del universo, ejerciendo una poderosa influencia sobre todo lo que existe a través del movimiento macrocircular. No necesariamente en un círculo perfecto, sino en un patrón de atracción central. Se concluye que el movimiento gravitacional macrocircular se revela en una dinámica universal de circuitos y patrones que observamos en todos los niveles de la realidad, desde las órbitas estelares, planetarias y satelitales hasta los movimientos de partículas subatómicas.

Palabras clave: Materia Oscura. Energía Oscura. Energía Universal. Cosmos. Movimiento Gravitacional Macrocircular. Fuerza Impulsora. Principio Organizador. Patrón de Atracción Central. Dinámica Universal.

RESUMEN

Esta investigación tiene como objetivo realizar un mapeo bibliométrico del cambio institucional relacionado con la sostenibilidad. Para ello, se realizó una búsqueda en las bases de datos Scopus, SciELO y Web of Science, utilizando la palabra clave "cambio institucional y energía y ciencia ambiental". La búsqueda se limitó a revistas científicas publicadas entre 2018 y 2022. El objetivo fue analizar el desempeño de los resultados bibliométricos, considerando diversos aspectos. El método empleado fue descriptivo, con el fin de transcribir, describir, interpretar y explicar los resultados obtenidos mediante el análisis bibliométrico. Esto busca identificar y analizar el perfil de la producción científica sobre un tema determinado, utilizando un enfoque cuantitativo a través de la estadística descriptiva. Desde la perspectiva de las redes bibliométricas, se observó, mediante el mapeo de palabras clave, que el tema investigado se inserta en diferentes contextos, divididos en tres aspectos: 1) cambio institucional, 2) estructura institucional y 3) sostenibilidad. Todos los artículos seleccionados señalan el cambio institucional como una de las acciones de mitigación en relación con el desarrollo sostenible. Este cambio implica la reestructuración de las instituciones. El proceso es lento y gradual debido a la existencia de mecanismos de resistencia, principalmente del sector económico, pero también, en parte, del sector académico. Los investigadores sostienen que los Objetivos de Desarrollo Sostenible (ODS) presentan una conceptualización limitada e inadecuada, lo que dificulta su aplicación práctica. Si bien buscan promover estándares sostenibles, los ODS no ofrecen metas claras ni una guía eficaz para los cambios institucionales necesarios. Los autores señalan la importancia de una visión holística de los desafíos y describen el modelo de microred basado en blockchain, proponiendo cambios tanto en las instituciones como en el entorno científico y académico.

Palabras clave: Cambio Institucional. Sostenibilidad. Bibliometría.

1 INTRODUCTION

Based on the concepts of dark matter and dark energy introduced by the Swiss astronomer Fritz Zwicky (1933) and the astrophysicist Michael Turner (1998), respectively, which exert a strong influence on cosmic bodies, in theory, as a gravitational glue that holds galaxies together and structures the universe, whose theses are fundamental to explain why galaxies are nothing more than organized structures to chaos, as well as explaining the accelerated expansion of the universe, among others, being the biggest enigmas of modern physics. Certainly it cannot be ignored that there is a colossal force of energy provided with inscrutable glory.

In this way, I present a hypothesis of universal reality without pretense of imposing an ultimate and/or absolute reality, but only as an expression of the restlessness of thought. I apologize in advance for the technicalities and misused terms, considering the lack of expertise in specific areas to infer such theories, however, the conceptions that disturb the soul generate the necessary boldness to share this alternative reality focus.

2 THE MACROCIRCULAR MOVEMENT

All the universal energy that organizes and sustains the cosmos is manifested in the macrocircular motion of the celestial bodies, as a driving force behind the motions of the galaxies, whose motions, in fact, do not represent an expansive linear motion, but the macrocircular motion of the center of gravitation, thus revealing the constant transformation and flux of the cosmos. Therefore, I suggest that there is a single, fundamental source of energy that drives movement and transformation across the entire expanse of the universe.

This gravitational center energy is responsible for the macrocircular motions of galaxies and underscores the dynamics and interconnectedness of the cosmos on its broadest scale. The patterns observed in the movement of galaxies are expressions of this energy that permeates the entire universe, shaping its evolution and structure throughout the cosmic moment.

The cosmos is an integrated and constantly moving whole, where each part is in dynamic interaction with all other cosmic units, although uniquely distinguished by the circular movement around its focal points (black holes) and existential momentum.

The interaction of all existential matter is sustained by the continuous macrocircular movement that predominates over all existence, this movement being the very pillar of existence, highlighting its dynamic and omnipresent nature. The gravitational center energy, therefore, is the organizing principle that maintains the cohesion and structure of the universe,

exerting a powerful influence on everything that exists through macrocircular motion. Not necessarily in a perfect circle, but in the centrally attractive pattern.

Without the continuous interaction of this universal movement, everything that came into existence would dissolve like smoke dissipated in the wind, which reveals the fragility and dependence of physical reality on this primordial force. This dependence suggests the transitory and ephemeral nature of material existence, contrasting it with the perennial presence of the gravitational center energy that sustains it. Without it, nothing that has been done would be done and, therefore, nothing would exist.

Thus, among the structures of the celestial bodies, what seems to be distancing itself at a given moment of existence will give the impression of approximation or stability of position, as can be observed with the impression of approximation of the Andromeda galaxy. This is due to the variation of imperfect circular movements throughout the cosmos, similar to what occurs with the translation of the planets and satellites of our Solar System, noticeable, because it occurs in a smaller amplitude of space and time.

That said, the end of interaction in circular motions is the end of all things. It would be the immediate resublimation of everything to nothingness, when existence would dissolve into nothingness of nothing, because even the nothingness of the cosmos is nothing without such constant and circular interaction of the influence of the gravitational center energy that translates into gravitational and organizational force.

Thus, within the thesis of the macrocircular motion of the cosmic structure, there is no distinction between the concepts of dark energy and dark matter, both energies coming from one, namely, the gravitational center energy. Such a circular force gravitational center, despite sustaining the gear of existence, is not represented by anything imaginable or detectable in physical perspective, such as a large black hole in the non-existent center of the universe or anything like that, even though its effects are undeniable on the structure of the universe, translated by dark energy and matter. Only what is existent moves in a circle around this gravitational center (the focal point still needs to be observed), revealing itself in a universal dynamic of circuits and patterns that we observe at all levels of reality, from stellar, planetary, satellite orbits to the movements of subatomic particles.

3 CONCLUSION

It is concluded, therefore, that there has not been a universal explosion, nor is there a linear expansion of the celestial bodies, but an imperfect macrocircular trajectory of the entire cosmic mass around the non-existent focal point of the gravitational center energy persists,

taking over all cosmic matter, similar to what is observable in the spirals of galaxies, which form their own circular motion by themselves. where the same principled movements and patterns manifest themselves in different scales that act in a constant and infinite force on all existing matter, whose levels of matter, from the subatomic to the astronomical, in all of them the interactive circle is replicated as a gear of existence.

Therefore, macrocircular motion is not just an observable phenomenon, but a basic principle that governs the interaction between energy and matter. This implies that this movement can be considered a fundamental characteristic of existential nature, present in all aspects of reality. Each part of the universe is interconnected and interdependent, contributing to the harmonious functioning of the whole. In this sense, macrocircular motion is not just an isolated feature, but an essential component of the complex web of interactions that sustain life, existence, and the organization of the universe. "Somehow, everything goes around."

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DIGITAL TRANSFORMATION IN CIVIL CONSTRUCTION: A PROPOSAL FOR THE IMPLEMENTATION OF CONSTRUCTION 4.0 IN SMALL COMPANIES

TRANSFORMAÇÃO DIGITAL NA CONSTRUÇÃO CIVIL: UMA PROPOSTA DE IMPLEMENTAÇÃO DA CONSTRUÇÃO 4.0 EM PEQUENAS EMPRESAS

TRANSFORMACIÓN DIGITAL EN LA CONSTRUCCIÓN CIVIL: UNA PROPUESTA DE IMPLEMENTACIÓN DE LA CONSTRUCCIÓN 4.0 EN PEQUEÑAS EMPRESAS



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ABSTRACT

This study investigates the transition of the construction industry to the Construction 4.0 paradigm, focusing on overcoming productivity stagnation and the sector's technological slowdown. The global scenario, driven by the Fourth Industrial Revolution, requires the integration of technologies such as BIM, drones, the Internet of Things, and cloud computing. However, the literature indicates that implementation is challenging, especially for small companies in developing countries, due to high costs, cultural resistance, and the lack of clear roadmaps. The case study conducted in a small construction company in Pernambuco highlights real issues, such as failures in façade inspection and critical incompatibilities between decentralized projects. To address these bottlenecks, an eleven-step methodology is proposed, using Revit software for BIM coordination, the OnSafety platform for digital occupational safety management, and the strategic use of drones for technical monitoring. The results demonstrate that digitalization is feasible and essential for small organizations, leading to greater operational efficiency, error reduction, and increased competitiveness in the regional market.

Keywords: IR4.0. Construction 4.0. Digital Solutions. Drones. Mobile Computing. BIM.

RESUMO

Este trabalho investiga a transição da indústria da construção para o paradigma da Construção 4.0, com foco em superar a estagnação da produtividade e a lentidão tecnológica do setor. O cenário global, impulsionado pela quarta revolução industrial, exige a integração de tecnologias como BIM, Drones, Internet das Coisas e Computação em Nuvem. Contudo, a literatura aponta que a implementação é desafiadora, especialmente em pequenas empresas de países em desenvolvimento, devido a custos elevados, resistência cultural e falta de roteiros claros. O estudo de caso realizado em uma construtora de pequeno porte em Pernambuco evidencia problemas reais, como falhas na inspeção de fachadas e incompatibilidades críticas entre projetos descentralizados. Para solucionar esses gargalos, propõe-se uma metodologia em onze etapas que utiliza o software Revit para

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compatibilização BIM, a plataforma OnSafety para gestão digital de segurança do trabalho e o uso estratégico de drones para monitoramento técnico. Os resultados demonstram que a digitalização é factível e essencial para pequenas organizações, resultando em maior eficiência operacional, redução de erros e aumento da competitividade no mercado regional.

Palavras-chave: IR4.0. Construção 4.0. Soluções Digitais. Drones. Computação Móvel. BIM.

RESUMEN

Este trabajo investiga la transición de la industria de la construcción hacia el paradigma de la Construcción 4.0, con foco en superar el estancamiento de la productividad y la lentitud tecnológica del sector. El escenario global, impulsado por la Cuarta Revolución Industrial, exige la integración de tecnologías como BIM, drones, Internet de las Cosas y computación en la nube. Sin embargo, la literatura señala que la implementación es desafiante, especialmente en pequeñas empresas de países en desarrollo, debido a los altos costos, la resistencia cultural y la falta de rutas claras. El estudio de caso realizado en una constructora de pequeño porte en Pernambuco evidencia problemas reales, como fallas en la inspección de fachadas e incompatibilidades críticas entre proyectos descentralizados. Para solucionar estos cuellos de botella, se propone una metodología en once etapas que utiliza el software Revit para la coordinación BIM, la plataforma OnSafety para la gestión digital de la seguridad laboral y el uso estratégico de drones para el monitoreo técnico. Los resultados demuestran que la digitalización es factible y esencial para pequeñas organizaciones, resultando en mayor eficiencia operativa, reducción de errores y aumento de la competitividad en el mercado regional.

Palabras clave: IR4.0. Construcción 4.0. Soluciones Digitales. Drones. Computación Móvil. BIM.

1 INTRODUCTION

The global industrial scenario has changed radically in recent years, as a result of continuous technological innovations (SCHMIDT *et al.* 2015). While the first three industrial revolutions leveraged productivity through disruptive technologies (SCHUH *et al.* (2013), Industry 4.0 (I4.0) introduced the concept of smart factories. This new paradigm encompasses advances such as Cyber-Physical Systems, Internet of Things (IoT), Robotics, Big Data, Cloud and Augmented Reality (WEYER *et al.* 2015), driven by the intense convergence between the digital, physical and biological worlds (LI *et al.* 2017).

In the field of civil construction, this concept gave rise to Construction 4.0. The literature extensively maps its applications: Oesterreich and Teuteberg (2016) point out 16 areas integrated into the sector, while Balasubramanian *et al.* (2021) reference at least 23. In a convergent way, Silva, Simão and Menezes (2018) summarize that the insertion of tools such as drones, cloud, augmented reality, 3D printing and BIM are promoting profound transformations in the work dynamics in civil construction (CC).

Although digitalization facilitates the construction and maintenance processes (MUSARAT *et al.* 2022), the sector has traditionally been slow to assimilate innovations (CAO; LI; WANG, 2014), failing to take advantage of technological opportunities capable of combating the productive stagnation of the workforce (MASKURIY *et al.* 2019). Aggravating this scenario, Menegon and Da Silva (2023) point out the difficulty of implementing Construction 4.0 in small companies in developing countries. The authors warn of a scientific gap, highlighting the urgency of adapting research to the local reality of emerging markets and their specific barriers.

The construction industry is highly fragmented, dominated by small and medium-sized companies with restricted budgets to invest in innovation, has obstacles such as high startup costs, training expenses, resistance to change, and technological immaturity often restrict I4.0 to purely experimental stages.

Similar to the panorama of general stagnation of the sector (MASKURIY *et al.* 2019), the construction company object of this study has a cultural aversion to change. The non-adoption of digital advances has generated severe bottlenecks, such as operational inefficiency, slow decisions, failures in project management, and consequent loss of competitiveness in the market.

However, the literature proves that these barriers can be mitigated. The application of I4.0 ensures greater efficiency on construction sites (MUSARAT *et al.* 2022), and the use of intelligent tools in supply management generates time savings and cost reduction (DARDOURI,

2022). Therefore, the adoption of these technologies presents itself as a viable and promising way to solve the problems of the company in focus.

The article presents a structure organized as follows: section 2 presents the theoretical framework with concepts and elements of IR4.0 and digital transformation in CC; Section 3 consists of a case study, with a proposal for the company studied; Section 4, finally, contemplates the conclusions of the study and final considerations of the work.

2 THEORETICAL FRAMEWORK

2.1 INDUSTRY 4.0 IN CIVIL CONSTRUCTION

IR4.0 created a paradigm shift in the construction industry towards digital transformation, this transition of the sector to a more advanced digitalization resulted in an innovative concept called Construction 4.0. The term Construction 4.0 was derived from the concept of Industry 4.0, which has its roots in the German manufacturing sector (OSUNSANMI; AIGBAVBOA; OKE, 2018). According to Musarat *et al.* (2022), digitalisation in the construction sector, has facilitated construction and maintenance processes. Not only in the execution phase, but digitalization is also in all other phases of construction projects, providing greater ease to builders. Musarat *et al.* (2022) also bring in their studies that the advent of IR 4.0 is essential for the smooth transformation of the construction industry towards digitalization.

Construction 4.0 adapts to the Industry 4.0 framework by incorporating cyber-physical systems and advanced digital technologies into its practice according to Sawhney *et al.* (2020). To align with Industry 4.0, CC needs to transform significantly, deploying technologies (SHAFEI *et al.*, 2022).

Information from the World Economic Forum (WEF, 2016) points out that the adoption of digital technology increases productivity, streamlines project management and procedures, and increases quality and safety; also in this line and as highlighted by CBIC (2016), the adoption of innovations is a viable option to better meet the demands of the civil construction sector. The use of innovations has several advantages, such as reducing labor costs, increasing productivity, and decreasing production costs.

According to Simão *et al.* (2019), to make this smart industry model viable, some crucial aspects are necessary, such as adaptability, optimization of the use of resources, and connection between all participants, from value generation to strategic implementation.

2.2 DIGITAL TRANSFORMATION IN THE CONSTRUCTION INDUSTRY

Digital transformation aims to improve an entity, generating significant changes in its characteristics through the use of information technology, computing, communication, and connectivity (VIAL, 2019). Digital transformation is unavoidable in the era of Industry 4.0. According to Brynjolfsson and Hitt (2000), digital transformation can improve organizational performance by providing products or services that adapt to customer preferences, increasing customer satisfaction and reducing costs. Change and transformation are driven by and built on digital technology.

According to Morakanyane *et al.* (2017), one of the effects of digital transformation on an organization is the development of competitive advantage. They also say that digital transformation should be viewed as a comprehensive organizational approach, rather than simply changing the way of operating from online to analog or from analog to digital. Digital transformation is seen as a continuous and never-ending process.

Verhoef *et al.* (2021) identify three main reasons why companies should digitally transform: evolution in digital technology, increased digital competition, and changes in consumer behavior in response to the digital revolution.

2.3 CONSTRUCTION 4.0

According to Musarat *et al.* (2022), digitalization is the new norm in the construction industry, following the adaptability of the fourth Industrial revolution. In the construction industry, digital transformation requires a variety of technologies, newly proposed methods utilizing digital technology for the development of the construction sector, energy optimization, sustainable environment, smart construction to deliver a better quality of life, economic and architectural growth, wireless technology for effective communication, and building maintenance (MUSARAT *et al.*, 2021).

Similar to the manufacturing sector, the construction sector can also be a major beneficiary of I4.0. The implementation of I4.0 will ensure that production efficiency is achieved through the utilization of advanced technologies, such as mechanized automation, to operate without human intervention. The benefits are quite obvious, as this implementation not only improves product quality, but also reduces distribution time, which will further increase the performance of the operation (NAWI *et al.*, 2021).

The transition to more advanced digitalization has resulted in an innovative concept called Construction 4.0. The term Construction 4.0 was derived from the concept of Industry 4.0, which has its roots in the German manufacturing sector (OSUNSANMI; AIGBAVBOA; OKE,

2018). Construction 4.0 adapts to the Industry 4.0 framework by incorporating cyber-physical systems and advanced digital technologies into its practice, according to Sawhney *et al.* (2020).

According to the World Economic Forum (WEF, 2016), the adoption of digital technology increases productivity, streamlines project management and procedures, and increases quality and safety. To align with Industrial 4.0, the CC industry needs to transform significantly, deploying technologies (SHAFEI *et al.*, 2022). The advent of I4.0 is essential for the smooth transformation of the construction industry towards digitalization (SUBRAMANIAN, 2022).

Digitalization in construction has transformed construction projects from planning to closure (WIJAYASEKERA, 2022) due to the involvement of various technologies such as automation, cybersecurity, Internet of Things, drones, Building Information Modeling (BIM), 3D printing, Augmented Reality, etc (MUSARAT *et al.*, 2022). Silva, Simão and Menezes (2018) summarize that the insertion of several technologies that are bringing significant changes in the way CC works are drones, cloud computing, augmented and virtual reality, additive manufacturing, BIM and automatic tracking.

While the construction industry has immense potential, the only way forward to achieve maximum efficiency and production is through the incorporation of new technologies, digitalization, and innovation for the construction industry. The incorporation of newly evolved industry tools that have already established themselves as successful aids to the construction industry, such as three-dimensional digitalization, the use of drones, and information modeling, should be incorporated into current practices and perceptions of the construction business, the path chosen to address these difficulties will be significantly improved (NAWI *et al.*, 2021).

The literature is broad regarding the concepts and applications of the various areas of IR4.0, such as the approach of the authors Tondelo and Barth (2019), Dos Santos, Mota and Zanlucas (2021) and Zhang *et al.* (2016), which in general address the areas of IR4.0 applied in CC with the themes: use of drones, BIM and mobile computing, respectively, whose areas were worked on in the case study below. Some authors and researchers bring important concepts and explain in the literature the various areas of construction 4.0, some relevant are:

Drones ₁ which are aircraft capable of flying without a human operator on board (FALORCA; LANZINHA, 2018) and that according to Mosly (2017), the use of this equipment can help reduce the time of activities, increase the quality of work, improve safety standards and reduce costs. Studies developed in the area by Nwaogu *et al.* (2023) bring a review of the literature corroborating and expanding these concepts.

The Internet of Things (IoT) which, according to Pataca (2021), is related to the ability of objects to communicate and transmit information about their state and operation. Filho (2016)

says that IoT technology consists of connecting objects of daily use in the real world with the Internet, transforming them into smart objects. Mishra, Lourenço and Ramana (2022) and Elghaish *et al.* (2021) review the literature delving into the topic.

According to Paz and Loos (2020), cloud computing allows the creation of new business models based on the data available in the cloud. This information allows users to predict the closure of production lines, schedule add-on lines remotely, and make adjustments in real time. Bello *et al.* (2021) and Ali *et al.* (2020) through their literature reviews bring other contributions to their studies in the area.

Building Information Modeling (BIM) offers tools to transform and improve project performance and productivity, decreasing inefficiencies and decreasing unproductivity, as well as increasing collaboration between different groups of project stakeholders (BURGESS; JONES; MUIR, 2018). Through a digital platform, BIM enables the teams involved in the project to share information, visualize the interactions between the project disciplines in an integrated way, and make decisions that improve project performance (MAHALINGAM; YADAV; VARAPRASAD, 2015). Recent research by Ramly, Mohamad and Noor (2023), Wang and Chen (2023), Caldart and Scheer (2022) and Avendaño *et al.* (2022) bring a relevant literature review on the tool.

Mobile computing is a computing paradigm that allows users to access and interact with data, applications, and services through handheld devices without the need for a physical connection to a fixed network or infrastructure. Andrade, Assis and Brochardt (2015) highlight the importance of using mobile devices, such as smartphones and tablets, to improve the flow of information on the construction site. Marques *et al.* (2020) and Nazir *et al.* (2019) also present research in the area.

According to Kirner and Kirner, (2011), computer interface techniques that incorporate three-dimensional space, such as virtual reality, augmented reality and their variations, allow the user a multisensory experience. Li *et al.* (2023), Muthalif, Shojaei, and Khoshelham (2022), and Cárdenas-Robledo *et al.* (2022) bring important research today in their literature reviews.

Finally, Additive manufacturing, which, according to Ngo *et al.* (2018), 3D printing consists of an additive manufacturing method used in the production of a wide range of complex structures and shapes, originating from information from three-dimensional models. This technique involves printing consecutive layers of materials to create the desired object. Other definitions and studies are characterized in the research of Gardner (2023), Pajonk *et al.* (2022), Raza and Zhong (2022) and Coelho *et al.* (2021), through their literature reviews.

3 CASE STUDY

3.1 PRESENTATION OF THE COMPANY

Despite a slow implementation, the construction industry has sought more support from technological innovations, recognizing the value of technology as a competitive differentiator. However, the fragmentation of the sector, with many small and medium-sized companies, as well as the challenges of implementing Industry 4.0, currently limit the application of technologies and keep the sector at an experimental stage. Digitalization of the construction industry, coordinated with high-level strategies and initiatives, can increase the competitiveness of the sector, improve operational efficiency, and generate significant benefits.

In this context, the company studied, in view of its problems and limitations, seeks greater competitiveness in the market, adopting technological solutions of construction 4.0. The company in focus is a small company, operating in the interior of the State of Pernambuco in the field of civil construction, has approximately 100 employees, routinely works with subcontractors, having its activity in the market since 2013. The company has 6 works in progress, in the cities of Paudalho, Buenos Aires and São Vicente Férrer, from the construction of multi-storey buildings, renovations of public buildings, paving in cobblestone and interlocked, basic sanitation, among other services.

It is a family business, culturally averse to change and that has not kept up with digital advances or adopted solutions that improve its construction, management or planning processes, as the scenario of recent years has required it to do, remaining stagnant in this sense. The situation of non-implementation of digital advances in the sector generates problems in the company such as: low operational efficiency, delays in decision-making, difficulties in project management and reduced competitiveness in the market due to lack of investment in digital solutions.

3.2 PROBLEMS FACED IN THE COMPANY

- Services with difficult access and inspection on facades

Image 01 shows past situations in which there was difficulty in relation to the inspection of various services. Image 01 shows the execution of a roof in a construction site in São Vicente Férrer-PE, whose access to the service is difficult and the engineer responsible for the visual inspection was unable to perform a satisfactory analysis of the services.

Figure 1*Installation of purlins in a roof*

Source: Author, 2023

As the company studied, it does not have the use of drones for inspection and inspection of these services. The use of drones would facilitate real-time monitoring of the execution of covering services and the inspection of employees in compliance with regulatory standards for work safety. It would also be possible to carry out visual inspection on building facades in order to identify possible pathological manifestations or construction defects.

- Incompatibility between projects

In 2020, the company in this study started the construction of a 3-story mixed building with a built area of 1115.00 m² in the city of Paudalho-PE, according to plans (Figures 02 and 03), the elaboration of the projects took place in a decentralized way, with different authors from the areas of architecture, structural calculation, electrical installations and hydrosanitary installations. Even after the critical analysis of the respective projects by the company's technical staff, during the execution of the work some incompatibilities between projects emerged, such as:

I. Compatibility between architectural and structural design

Conflict: BWC Soc. window positioned entering Pillar P07.

Location: apartments 01, 03 and 05.

Procedure performed: Move the window back facing the pillar.

II. Compatibility between the design of electrical installations and hydrosanitary installations

Conflict: Intersection between conduit and air conditioning drain pipe in the wall

Location: apartments 01 to 06.

Procedure performed: Conduit repositioning.

III. Compatibility between structural and plumbing installations

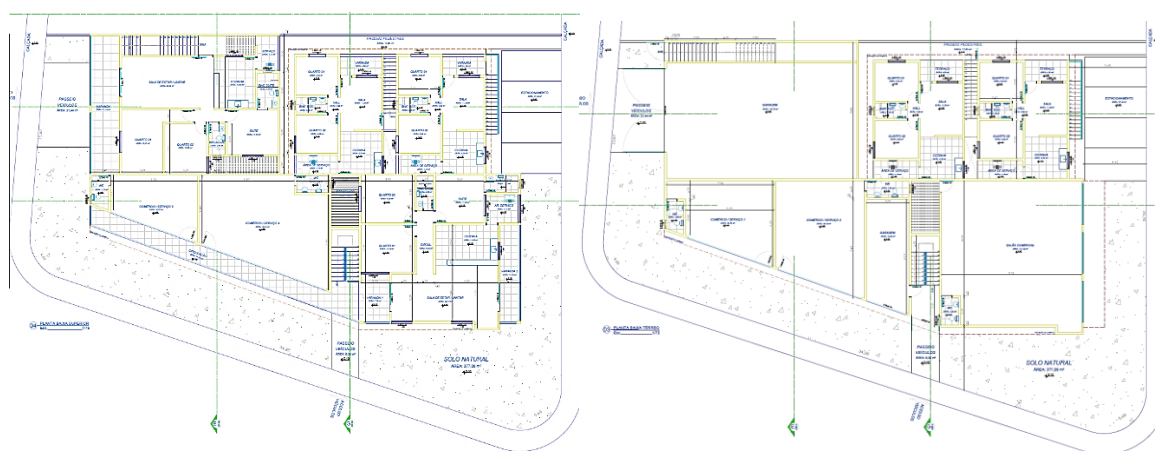
Conflict: Crossing between sewer pipe and V50 beam, in which its section height did not allow the passage of the DN100 sewer pipe.

Location: ground floor.

Procedure performed: Change in the structural design with adjustment in the height of the beam.

Figure 2

Ground floor plan Figure 03 – Upper floor plan



Source: Author, 2023.

This situation confirms the studies by Dos Santos, Mota, and Zanlucas (2021) that during the execution of projects (hydraulic, structural, and electrical), many elements end up generating physical and functional conflicts, due to the constraints of each system. These unresolved interferences in the design phase caused interruptions in construction for project review, or the need for sudden decision-making on site, disfavoring work and the optimization of time and resources.

- Mechanical processes in the management of workers' safety and health

The company studied uses mechanical processes on paper for all its management of workers' safety and health (OSH), such as: control and delivery of personal protective equipment (PPE), employee training, reports and records of evidence and non-conformities and the safety inspection checklist.

This methodology, already outdated, generates delays, does not bring effectiveness in the decision-making process, as well as limits and delays access to information.

3.3 PROPOSAL FOR SOLVING THE PROBLEM IN THE COMPANY

Considering the size of the company under study and the problems it faces in its projects, a proposal was prepared for the adoption of digital tools and solutions for the company, such as: use of drones, implementation of BIM and use of mobile computing.

The use of BIM technology will take place with the use of Autodesk's Revit software (2023), to make projects compatible, on a multidimensional platform, also adding to the *software* the OrçaBIM plugin from the company 3F Ltda – OrçaFascio, obtaining more expressive results in combination with the budget of works.

The company will be offered drone equipment for monitoring the works, services where there is difficult access and inspection of facades, the company will be proposed the acquisition of an intermediate-sized, long-range model, flight time duration over 30 minutes and a high-definition camera.

The use of mobile computing for the OSH management area will be carried out by a mobile solution tool that facilitates integration, collection and communication in the area of Occupational Safety. The company's engineering, occupational safety and management team opted for the adoption of the *OnSafety* platform from Lean Tecnologia e Engenharia LTDA. With the implementation of this tool, it will be possible to digitize the area of worker safety and health management in the company. Obsolete mechanical processes will be replaced by a set of digital solutions, such as: digital PPE sheet, issuance of inspection reports, CIPA documentation, Registration Control for Employees, among others. The software allows everyone involved to use the same *workflows* to monitor the workplace, required training, the control and delivery of PPE, health monitoring, among other documents and requirements. It also allows the management of OSH audits carried out in the work environment, ensuring more effectiveness in the decision-making process and access to information and reports on different devices.

With the adoption of established digital tools and solutions and the objectives of implementing these solutions in the company defined in: Increased operational efficiency; Improved decision-making; Improvement of project management; Innovation and competitiveness and Training and professional development, it is possible to propose a sequencing of steps for the implementation of these solutions in the company studied with the proposals:

- 1) Acquisition of equipment and software;
- 2) Internal and external training and training in the areas addressed;
- 3) Implementation and use of technology;
- 4) Communication and engagement: Monthly meetings with teams to discuss advances, challenges, and results. Internal newsletters highlighting the benefits and improvements achieved with digital solutions and dissemination of innovations and results on the company's social networks and communication channels.
- 5) Evaluation and continuous improvement: Conduct quarterly evaluations of the results obtained with digital solutions. Identify areas for improvement and promote adjustments and optimizations in the processes and solutions implemented. Establish partnerships with specialized companies and institutions to stay up-to-date on new technologies and trends

4 CONCLUSIONS

As shown in the literature explained, IR4.0 brings several aspects, concepts and new technologies to the construction industry. Digital transformation in civil construction is inevitable.

The case study addressed here shows that it is feasible to implement digital solutions in the company through the problem solving proposals presented here. The adoption of drones for façade inspection can be an efficient and economical tool for the early detection of problems in buildings, as well as their use in services where there is difficult access, being possible and beneficial their implementation in the company.

It is also feasible to implement the BIM tool in the company, given that as Dos Santos, Mota and Zanlucas (2021) show, there are several advantages that the use of this technology includes, such as agility in compatibility, automatic analysis of problems between elements, effective communication between processes and the significant reduction of errors in the project. Matching helps prevent problems from being discovered during construction, which can result in unplanned costs and delays in correcting these flaws.

On another point, similarly to Zhang *et al.* (2016), addressed in their research that an innovative IT-based solution for site safety inspection approach not only eliminates redundant paper-based systems, but also improves the coordination and integration of information between safety inspection procedures and other safety management strategies, today intelligent mobile computing software and tools are possible to implement in construction companies, such as the *OnSafety* platform, presented.

The effective adoption of these digital solutions proposed for the construction company under study will put into practice the company's quest to incorporate areas of construction 4.0, reaping benefits that can be raised in future studies.

During the process of preparing this article, some limitations were identified, such as the lack of similar case studies in the researched literature and the scarce application of the IR4.0 areas addressed here in small construction companies. As a limitation of the study, the analysis of this study is valid only for the case that was investigated, and cannot be generalized to other situations.

The development of this article encourages the exploration of other areas of IR4.0 that could not be implemented or proposed in the company studied. It is therefore suggested that future studies develop similar studies in small companies in the CC sector with other adoptions of digital solutions.

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THE EFFECTIVENESS OF EXTERNAL OVERSIGHT OF POLICE ACTIVITY BY THE PUBLIC PROSECUTION SERVICE: STATE LETHALITY AND INSTITUTIONAL GUARANTEES IN BRAZILIAN CONSTITUTIONALISM

A EFETIVIDADE DO CONTROLE EXTERNO DA ATIVIDADE POLICIAL PELO MINISTÉRIO PÚBLICO: LETALIDADE ESTATAL E GARANTIAS INSTITUCIONAIS NO CONSTITUCIONALISMO BRASILEIRO

LA EFECTIVIDAD DEL CONTROL EXTERNO DE LA ACTIVIDAD POLICIAL POR EL MINISTERIO PÚBLICO: LETALIDAD ESTATAL Y GARANTÍAS INSTITUCIONALES EN EL CONSTITUCIONALISMO BRASILEÑO



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ABSTRACT

This article examines the external oversight of police activity as a constitutional function assigned to the Public Prosecutor's Office, analyzing its normative foundations, structural limits, and the recurring problem of effectiveness in the Brazilian context. It starts from the understanding that effectiveness is not to be confused with mere procedural compliance, but rather with the institutional capacity to produce verifiable results, prevent violations of fundamental rights, and break structural patterns of state violence. The study identifies central bottlenecks in the traditional model, such as informational dependence on police corporations, the fragmentation of diffuse oversight, structural insufficiency, and the bureaucratization of institutional practices, all of which contribute to the reproduction of impunity and penal selectivity. In light of the Inter-American Human Rights System, with particular emphasis on the case of Favela Nova Brasília v. Brazil, and of the case law of the Brazilian Federal Supreme Court in ADPF 635/RJ, the article argues that external oversight is an indispensable institutional guarantee for reducing police lethality, protecting the right to life, and strengthening the democratic legitimacy of justice institutions.

Keywords: Public Prosecutor's Office. Police Lethality. Human Rights. Institutional Effectiveness. External Oversight.

RESUMO

Examina-se o controle externo da atividade policial como função constitucional atribuída ao Ministério Público, analisando seus fundamentos normativos, seus limites estruturais e o problema recorrente da efetividade no contexto brasileiro. Parte-se da compreensão de que

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a efetividade não se confunde com a mera observância procedimental, mas com a capacidade institucional de produzir resultados verificáveis, prevenir violações de direitos fundamentais e romper padrões estruturais de violência estatal. São identificados gargalos centrais do modelo tradicional, como a dependência informacional em relação às corporações policiais, a fragmentação do controle difuso, a insuficiência estrutural e a burocratização das práticas institucionais, fatores que contribuem para a reprodução da impunidade e da seletividade penal. À luz do Sistema Interamericano de Direitos Humanos, com destaque para o caso *Favela Nova Brasília vs. Brasil*, e da jurisprudência do Supremo Tribunal Federal na ADPF 635/RJ, sustenta-se que o controle externo é garantia institucional indispensável à redução da letalidade policial, à proteção do direito à vida e ao fortalecimento da legitimidade democrática das instituições de justiça.

Palavras-chave: Ministério Público. Letalidade Policial. Direitos Humanos. Efetividade Institucional. Controle Externo.

RESUMEN

Se examina el control externo de la actividad policial como función constitucional atribuida al Ministerio Público, analizando sus fundamentos normativos, sus límites estructurales y el problema recurrente de la efectividad en el contexto brasileño. Se parte de la comprensión de que la efectividad no se confunde con la mera observancia procedimental, sino con la capacidad institucional de producir resultados verificables, prevenir violaciones de derechos fundamentales y romper patrones estructurales de violencia estatal. Se identifican obstáculos centrales del modelo tradicional, tales como la dependencia informacional respecto de las corporaciones policiales, la fragmentación del control difuso, la insuficiencia estructural y la burocratización de las prácticas institucionales, factores que contribuyen a la reproducción de la impunidad y de la selectividad penal. A la luz del Sistema Interamericano de Derechos Humanos, con especial énfasis en el caso *Favela Nova Brasília vs. Brasil*, y de la jurisprudencia del Supremo Tribunal Federal brasileño en la ADPF 635/RJ, se sostiene que el control externo constituye una garantía institucional indispensable para la reducción de la letalidad policial, la protección del derecho a la vida y el fortalecimiento de la legitimidad democrática de las instituciones de justicia.

Palabras clave: Ministerio Público. Letalidad Policial. Derechos Humanos. Efectividad Institucional. Control Externo.

1 INTRODUCTION

Police action occupies a central place in the conformation of the contemporary State, as it represents one of the most intense expressions of State power over bodies, territories and individual freedoms. In the Brazilian context, marked by deep social, racial, and territorial inequalities, police activity has historically developed under permanent tensions between the constitutional promise of the protection of fundamental rights and institutional practices that naturalize the excessive use of force, criminal selectivity, and low accountability for abuses (Vieira, 2025).

The 1988 Constitution, by instituting the Democratic Rule of Law, broke with authoritarian models of public security and enshrined mechanisms of legal-institutional control of police action, among which the external control exercised by the Public Prosecutor's Office stands out, conceived as a structural guarantee of legality, democracy, and protection of human rights (Camelo, 2025).

The scientific and social relevance of this article, therefore, stems from the persistence of high rates of police lethality, the recurrence of violations of fundamental rights, and the historical difficulty of implementing effective accountability mechanisms in the context of public security. Despite the express constitutional provision for external control of police activity, there is a mismatch between the normative design of the institute and its practical implementation, often limited by structural, institutional and cultural obstacles.

In view of this scenario, the following problem emerges: why is external control of police activity, although constitutionally guaranteed and internationally required, low effectiveness in containing police violence and holding abuses accountable in Brazil?

In view of this question, the general objective of this article is to critically analyze the effectiveness of the external control of police activity exercised by the Public Prosecutor's Office, in the light of the 1988 Constitution and the parameters of the Inter-American Human Rights System. As specific objectives, it seeks to examine the constitutional and institutional foundations of the external control of police activity in the Brazilian legal system, to identify the main structural, informational and organizational bottlenecks that empty the effectiveness of this control and to evaluate the contribution of inter-American jurisprudence and ADPF 635/RJ in the redefinition of normative and institutional parameters aimed at reducing police lethality and strengthening the democratic accountability.

A qualitative methodology is then adopted, of a bibliographic and documentary nature, based on the analysis of doctrinal works, scientific articles, institutional documents, national and international judicial decisions duly referenced.

By problematizing the limits and challenges of external control of police activity, its main intention is to contribute to the deepening of the academic and institutional debate on the democratization of public security in Brazil, based on the premise that the effectiveness of external control is not a mere administrative requirement, but an indispensable condition for the realization of the right to life, of the dignity of the human person and the legitimacy of the Democratic Rule of Law itself, requiring critical reflection, institutional commitment and structural transformation of control and accountability practices.

2 CONSTITUTIONAL AND CONCEPTUAL FOUNDATIONS OF EXTERNAL CONTROL OF POLICE ACTIVITY

Understanding the constitutional foundations of external control of police activity requires, as an inescapable starting point, the systematic reading of the 1988 Constitution of the Republic as a normative project committed to overcoming authoritarian practices historically rooted in the exercise of state power, especially in the performance of coercive apparatuses.

The 1988 Charter was not limited to reorganizing institutional competencies or listing fundamental rights in the abstract, but promoted a profound reconfiguration of the State model, erecting the Democratic Rule of Law as the structuring axis of the Brazilian legal and political order.

Under this prognosis, police activity is no longer conceived as a space of broad discretion or institutional self-sufficiency and is now legally conditioned by a complex system of normative limits, constitutional principles and control mechanisms, since the Constitution recognizes public security as a duty of the State and a fundamental right of the collectivity, but does so in a manner that is inseparable from the protection of the dignity of the human person. due process of law and the full submission of state action to constitutional legality (Pinho; Chaves; Cruz 2024).

This constitutive tension between security and freedom, far from being a defect of the constitutional model, represents precisely its essential democratic trait, as highlighted in the specialized literature when dealing with the political and legal need to control police activity in democratic societies (Ávila, 2014).

It is in this context that article 129, VII, of the Federal Constitution is inserted, by attributing to the Public Prosecutor's Office the function of exercising external control of police activity (Brasil, 1998). The original constituent's option to expressly enshrine this attribution cannot be understood as a merely symbolic or redundant gesture, nor as a simple unfolding of the ownership of the public criminal action.

On the contrary, it is a conscious normative choice, guided by the perception that the police power, due to the nature of its functions and the intensity of the restrictions it imposes on fundamental rights, demands permanent, institutionalized external control endowed with functional autonomy.

The normative density of the expression "external control", then, is denoted precisely in the distinction that the Constitution establishes between generic control of legality and specific mechanisms of containment and accountability of armed organs of the State. As Sousa Júnior (2015) observes, the external control of police activity stems directly from the constitutional mission of the Public Prosecutor's Office to defend the legal order, the democratic regime and the inalienable social and individual interests, and is not limited to formal practices of procedural monitoring or episodic interventions. In fact, external control assumes a structural nature, aimed at correcting deviations, preventing arbitrariness, and promoting state accountability.

Regarding this type of control, Ávila (2014), in his Thesis, initially highlights attributions and tools of the Public Prosecutor's Office to exercise them through Complementary Law No. 75/1993, which:

The specific tools for the Public Prosecutor's Office in the exercise of external control of police activity are regulated in LC No. 75/1993, 9, which provides for free entry into police establishments, **access to any documents related to the police core activity**, the possibility of representing the competent authority for the adoption of measures to remedy the undue omission, or to **prevent or correct illegality or abuse of power, power to request the competent authority to initiate a police investigation into the omission or lawful fact that occurred in the exercise of police activity and also to promote criminal action for abuse of power**. The provision indicates that the exercise of external control can occur through judicial or extrajudicial measures (Ávila, 2014, p. 543, emphasis added).

This reading is reinforced when one considers the place occupied by the Public Prosecutor's Office in the constitutional design of 1988, since, instituted as a permanent body, essential to the jurisdictional function of the State and endowed with functional, administrative and financial autonomy, this important body is not subordinated to any of the Powers of the Republic, which gives it a unique institutional position for the exercise of the aforementioned control functions. Such autonomy is not justified as a corporate privilege, but as an institutional guarantee aimed at protecting society from abuses of state power, especially in contexts in which police action has a more intense impact on vulnerable populations (Morais Júnior, 2022).

The constitutional provision for external control of police activity must, therefore, be interpreted in conjunction with the structuring principles of the Democratic Rule of Law, notably legality, the separation of powers, the protection of fundamental rights and the republican

principle of the responsibility of public agents, and there is, therefore, no room to conceive of the police as an instance immune to external controls or as a neutral technical body whose action would be legitimized exclusively by internal efficiency criteria (Basilio; Basílio, 2023).

Thus, the Constitution breaks with this logic by stating that all state activity, including police activity, is subject to mechanisms of legal and institutional control, especially when it involves the legitimate use of force, and it can be clarified that practices of police arbitrariness cannot be explained only by individual deviations or moral failures of isolated agents.

There are, as Ávila (2014) and Vieira (2025) point out, sociological and organizational factors that make police activity particularly susceptible to abuses, such as the valorization of authority, the naturalization of violence as an instrument of efficiency, and the existence of institutional subcultures resistant to transparency and accountability, and it is precisely in this scenario that external control assumes the status of indispensable as a mechanism for the structural containment of deviance, and not only as a subsequent response to consummated violations.

In these terms, the external control of police activity is not to be confused with undue interference in the functional autonomy of police corporations, nor does it imply hierarchical subordination, since it is a legal-institutional control that preserves the technical autonomy of the police, but submits it to constitutional legality and the democratic parameters of state action. As Braga (2023) points out, the effectiveness of external control is directly related to the ability of the Public Prosecutor's Office to act independently, including through the adoption of its own extrajudicial and investigative instruments, especially in contexts in which police action is the object of suspicion.

The constitutional density of external control is also evident when one observes its connection with international commitments assumed by the Brazilian State in the field of human rights and, although this dimension will be deepened in its own chapter, it is important to recognize from the outset that the 1988 Constitution was open to international human rights law, incorporating standards of independent investigation, diligent and impartial in cases of serious violations. The external control of police activity, therefore, operates as a bridge between the internal constitutional order and the international obligations of the State, reinforcing its qualified legal nature and its centrality in the system of guarantees.

In view of this, the reading of article 129, VII, of the Constitution cannot be reduced to a minimalist or bureaucratic understanding of external control, but as a constitutional function endowed with its own normative density, whose purpose is to ensure that the exercise of police power remains compatible with the values of the Democratic Rule of Law (Corrêa; Coutinho,

2019). The performance of the Public Prosecutor's Office, in this field, must be understood as an expression of a control model that seeks to prevent abuses, correct illegalities, promote accountability and, above all, preserve the democratic legitimacy of state action.

This understanding opens the way for the examination, following this chapter, of the role of the Public Prosecutor's Office as an institution external to the police apparatus and an institutional guarantee of fundamental rights, as well as the distinction between merely formal supervision and corrective legality control, and it is from this constitutional basis that it is possible to critically evaluate the limits and potentialities of external control of police activity in the contemporary Brazilian context.

The relevance of external control of police activity, from the perspective of the defense of constitutional rights, is projected even more clearly when one examines the role of the Public Prosecutor's Office as the institutional guardian of these rights in the daily life of social relations, since the 1988 Constitution attributed to the Public Prosecutor's Office not only the function of promoting criminal prosecution, but, more broadly, the task of ensuring the effective respect of the public authorities for the rights guaranteed by the constitution, even more so when it comes to selective, discriminatory police stops and cases of lethal police violence, that is, with situations with deaths, as pointed out by Morais Júnior (2022).

Morais Júnior (2022), still under the constitutional molds, highlights that:

The framework proposed by the Public Prosecutor's Office by the original constituent power, therefore, enshrines the notion that the external exercise of the activity must be guided by the strengthening of citizenship and the dignity of the human person, as the foundations of the Federative Republic of Brazil, as well as by the presumption of a just, free and solidary society, as well as by the promotion of the good of all, without prejudice of origin, race, sex, color, age and any other forms of discrimination. [...] Thus, it follows the importance of police agencies being subject to effective supervision by the Public Prosecutor's Office, in view of the existence of multiple mechanisms for balancing state powers, within a Democratic State of Law [...] (Morais Júnior, 2022, p. 64-65).

This attribution gives external control a dimension that goes beyond the strictly repressive logic, placing it as an instrument of preventive and corrective protection of fundamental rights in the face of the exercise of police power, especially in contexts of social asymmetry and structural vulnerability, in which state action tends to have a selective and unequal impact (Morais Júnior, 2022).

Therefore, the defense of constitutional rights, in the context of external control, is not limited to the subsequent reaction to consummated abuses, but involves permanent vigilance over patterns of police action that may compromise the dignity of the human person, equality

before the law and due process of law. The performance of the Public Prosecutor's Office thus assumes a structural character, aimed at containing institutional practices that naturalize the violation of rights under the argument of efficiency or maintenance of order.

As Sousa Júnior (2015) points out, external control should be understood as a mechanism of collective guarantee, capable of stressing administrative routines, investigative procedures and forms of police approach that, although formally legitimized, produce material effects incompatible with the democratic constitutional project.

For society, this action has relevance that transcends the technical-legal sphere, as it contributes to the construction of a public security model committed to legality, transparency and accountability. The external control exercised by the Public Prosecutor's Office operates as an instrument of institutional mediation between the coercive power of the State and the fundamental rights of the population, reinforcing social trust in institutions and reducing the risk that police action will become a factor in the reproduction of inequalities and state violence. By assuming this function, the Public Prosecutor's Office reaffirms its constitutional vocation as an agent of social transformation, whose legitimacy derives not from the arbitrary exercise of power, but from the intransigent defense of the constitutional order and the rights that give it material meaning (Ávila, 2014).

2.1 THE PUBLIC PROSECUTOR'S OFFICE AS AN EXTERNAL INSTITUTION OF GUARANTEE IN THE CONSTITUTIONAL SYSTEM

The centrality of external control of police activity in the Brazilian constitutional design leads, logically, to the analysis of the institutional role of the Public Prosecutor's Office as an external instance of guarantee in the constitutional system, but this condition does not result only from the express provision of article 129, VII, of the Constitution, but from the very configuration of the Public Prosecutor's Office as an independent body, permanent and essential to the jurisdictional function of the State, responsible for the defense of the legal order, the democratic regime and the inalienable social and individual interests. The role of the Public Prosecutor's Office in the control of police activity, therefore, cannot be understood as an accessory or derivative function, but as a direct expression of its structuring constitutional mission, as already described.

The idea of an external institution of guarantee presupposes the existence of an organ endowed with sufficient autonomy to exercise control over state structures that concentrate coercive power, without hierarchical subjection or functional dependence. In the case of police activity, this requirement is particularly important, since it is a state apparatus authorized to

restrict fundamental rights in an immediate and concrete way, including through the legitimate use of force (Ávila, 2014; Padilha, 2020).

Padilha (2020, p. 845) shifts attention to a socio-legal attribution of the Public Prosecutor's Office regarding external control over police activities, since this important body was appointed "*ombudsman*" of Constitutional Law, with the obligation to act in a strictly impartial manner in defense of citizens, citing the understanding of the Supreme Court, which:

The Federal Supreme Court has already stated, more than once, that the Public Prosecutor's Office has the legitimacy to promote investigative acts, thanks, among other grounds, to the **theory of implicit powers, that is, when the Constitution grants the ends to certain bodies, it implicitly grants them the means to fulfill the constitutionally proposed objectives**. Translating: if the Constitution grants the Public Prosecutor's Office powers to promote criminal action, it must implicitly grant him the means to form his *opinio delicti* (Padilha, 2020, p. 846-847, emphasis added).

The 1988 Constitution, by removing the Public Prosecutor's Office from organic links with the Executive, Legislative and Judiciary Branches, created the institutional conditions necessary for the control of police activity to be exercised by an agency external to the police corporations and immune to direct political-administrative pressures, reinforcing the democratic rationality of the system of checks and balances (Sousa Júnior, 2015).

On the other hand, this external position does not entail institutional antagonism, but translates a logic of republican control based on responsibility and accountability. The Public Prosecutor's Office does not replace the police in their constitutional functions, nor does it assume the day-to-day management of public security, given that its performance focuses on the legality, legitimacy and constitutional conformity of the acts performed, functioning as an instance of containment of excesses and correction of deviations that, if not addressed, compromise the legitimacy of the entire security policy.

As Ávila (2014) observes, external control is an indispensable element to prevent police activity from developing in a space of institutional self-sufficiency, in which illegal or abusive practices are naturalized as inevitable costs of repressive efficiency.

The condition of the Public Prosecutor's Office as a guarantee institution is not limited to subsequent repressive action, but involves the ability to intervene in a preventive and structural manner. This means that external control must focus on standards of action, workflows, operational protocols, and repeated practices that affect fundamental rights, and not just on isolated cases of abuse.

From this perspective, the Public Prosecutor's Office acts as an institutional mediator between the police power and society, translating social demands for legality, equality, and

respect for human rights into legal parameters required within the scope of state action (Braga, 2023).

The notion of institutional guarantee is also articulated with the collective dimension of fundamental rights. The role of the Public Prosecutor's Office in external control is not only aimed at the protection of individual rights violated in specific situations, but also at the protection of legal assets of a diffuse and collective nature, such as the democratic legitimacy of police action and social trust in public security institutions.

When selective, discriminatory or violent police practices are perpetuated without effective control, the damage produced is not restricted to the direct victims, but reaches society as a whole, eroding the credibility of the State and deepening structural inequalities, and it is in this scenario that the external control exercised by the Public Prosecutor's Office assumes the function of defending the constitutional order in its material sense, by preventing the exercise of coercive power from moving away from the values that legitimize its existence (Morais Júnior, 2022).

In addition, the condition of the Public Prosecutor's Office as an external guarantee institution is projected on its ability to articulate judicial and extrajudicial instruments in an integrated manner, not exhausting external control in the provocation of the Judiciary, and comprising the use of administrative mechanisms, recommendations, inspections, requests and its own investigative procedures, always guided by the purpose of ensuring the constitutional conformity of police activity (Greco, 2022).

This multifaceted performance reinforces the idea that the Public Prosecutor's Office does not operate only as an organ of prosecution, but as an institutional agent dedicated to the protection of rights and the induction of state practices compatible with the Democratic Rule of Law (Sousa Júnior, 2015).

Consequently, the relevance of the Public Prosecutor's Office as an external institution of guarantee is particularly noticeable in contexts of social vulnerability and historical marginalization, in the aspect that police action tends to have a more intense impact on certain social groups, reproducing selective and discriminatory patterns that challenge the constitutional promise of equality (Morais Júnior, 2022; Vieira, 2025).

In these scenarios, external control remains essential in the containment of practices that, although formally justified under the discourse of security, produce systematic violations of fundamental rights and, by exercising this function, the Public Prosecutor's Office reaffirms its constitutional vocation as a defender of society and a promoter of social justice, consolidating

itself as a key piece in the institutional architecture for the protection of constitutional rights in contemporary Brazil.

3 STRUCTURAL LIMITS OF THE TRADITIONAL MODEL AND THE PROBLEM OF EFFECTIVENESS: INSTITUTIONAL AND OPERATIONAL BOTTLENECKS

The discussion about the effectiveness of external control of police activity requires, first of all, a conceptual shift that moves away from merely formal or procedural readings of the institute. At the constitutional level, the attribution conferred on the Public Prosecutor's Office is not limited to the ritual observance of administrative flows, the episodic issuance of recommendations or the simple establishment of follow-up procedures.

Effectiveness, understood here in a material sense, must first be measured by the concrete capacity to produce verifiable institutional results, capable of preventing violations, correcting deviant patterns of police action and inducing structural transformations in the way state force is exercised in everyday social life, referring, therefore, to a notion that is directly linked to the idea of democratic accountability, in which control is not legitimized by its normative statement, but by its real ability to impact practices, reduce arbitrariness and strengthen public confidence in the institutions of justice (Cavallazzi; Suxberger, 2019).

Cavallazzi and Suxberger (2019) understand accountability as a result of the ministerial focus given to the body dimensioned here due to the extension of existing social relations in daily life and the indispensability of greater transparency and improvement of the institutions that are linked to the justice system, which will also lack the confidence of citizens about the way in which the society in which they live is governed, that is, in the laws in force. Furthermore, it is important to consider, according to the authors, that:

The idea of *accountability*, brought to the current context, can be understood as the set of elements indicative of transparency and social control over state action. It is possible to number that the sense of *accountability* involves responsibility (objective and subjective), control, transparency, accountability obligation, justification for actions that were or left understood, reward and/or punishment. It is clear that there are advances in the field of external control, but changes of a greater scope, of a cultural nature, still pending realization, after all, *accountability*, more than a desired characteristic or attribute of state action, is the result of an *institutional culture* that is still distant from the Brazilian reality (Cavallazzi; Suxberger, 2019, p. 231).

That said, the effectiveness of external control cannot be confused with the mere existence of formal competences or with the multiplication of instances of abstract inspection, insofar as it presupposes an institutional action capable of breaking with the defensive and self-

centered logic that historically marks public security systems, especially in contexts of high police lethality and criminal selectivity.

The production of verifiable results thus generates the ability to access qualified information, to formulate consistent diagnoses on patterns of police action and to adopt corrective measures endowed with sufficient institutional strength to change repeated conducts. When control is limited to reacting to isolated cases, without reaching the structural dynamics that produce state violence, it tends to assume a symbolic character, which preserves the appearance of legality without facing the root causes of ineffectiveness (Cavallazzi; Suxberger, 2019).

However, it is important to point out that one of the main bottlenecks that empty external control lies in the informational dependence of the Public Prosecutor's Office in relation to the police corporations themselves, given that, to a large extent, the exercise of control is still structured from data produced, filtered and systematized by the institutions that should be inspected, which compromises the cognitive autonomy necessary for effective inspection (Pedrosa Júnior; Monteiro; Nascimento, 2023).

This informational asymmetry then goes from a technical problem to a structural obstacle that limits the ability of the control body to identify hidden patterns of abuse, underreporting of occurrences or statistical distortions. Let us imagine, then, that when the flow of information remains under the monopoly of the controlled entity, the control tends to operate in a reactive, fragmented and often late manner, unable to anticipate risks or to intervene preventively in scenarios of systematic violation of rights.

The fragmentation of diffuse control is another central element in understanding the ineffectiveness of the traditional model. Although the Constitution has assigned to the Public Prosecutor's Office a leading role in the external control of police activity, institutional action is often dispersed in isolated initiatives, dependent on the individual actions of members, without the consolidation of integrated strategies and long-term institutional policies (Cavallazzi; Suxberger, 2019; Camelo, 2025).

The aforementioned dispersion can also hinder the construction of a robust institutional memory, as well as the definition of clear priorities guided by objective criteria of risk, social impact and severity of violations, as evidenced by Ávila (2014). As a consequence, control tends to oscillate between periods of greater activism and phases of retraction, without achieving the continuity necessary for the structural transformation of police practices.

No less important to discuss, the overload of attributions, the scarcity of specialized technical teams, and the absence of systematic investments in institutional intelligence

compromise the agency's ability to exercise qualified and permanent control, a point raised by Ávila (2014) and Braga (2023), and the authors collaborate in understanding that, in many contexts, Ministerial action is tensioned between immediate repressive demands and the need for structural oversight of police activity, which ends up prioritizing punctual responses to the detriment of medium and long-term strategic actions. This material limitation reinforces the tendency towards the bureaucratization of control, converting inspection procedures into administrative routines that are not very sensitive to the concrete dynamics of state violence.

The bureaucratization of institutional practices, in turn, represents a paradox in the exercise of external control, since, although the formalization of procedures is indispensable for legal certainty and the predictability of state action, the excess of administrative rituals can produce a progressive distancing between the control exercised and the social reality that it should transform (Ávila, 2014; Vieira, 2025).

When the focus of action shifts to meeting deadlines, standardizing forms, and producing reports detached from concrete impacts, control loses its critical and emancipatory dimension. With this, formal legality is preserved, but material effectiveness remains compromised, reproducing the social sensation of impunity and the absence of real accountability for abuses committed in the exercise of police function.

The impacts of this ineffectiveness are not restricted to the institutional level, but are projected in a profound way on the structure of the penal system and on the legitimacy of justice institutions. The inability to adequately control police activity contributes to the reproduction of selective practices, which disproportionately affect historically vulnerable groups, reinforcing patterns of racial, territorial and socioeconomic discrimination (Viegas; Loureiro; Abrucio, 2022; Vieira, 2025).

Criminal selectivity, in this context, represents a systemic effect of a control model incapable of breaking with the logic of exception that guides certain forms of police action, where the absence of consistent institutional responses to abuses reinforces the perception that certain lives are less protected by the law, eroding the egalitarian foundations of the Democratic Rule of Law (Vieira, 2025).

The crisis of legitimacy of justice institutions thus emerges as a direct consequence of the ineffectiveness of external control. When society realizes that the inspection mechanisms do not produce real changes, a diffuse feeling of discredit is installed that affects not only the Public Prosecutor's Office, but the entire criminal justice system.

This discredit weakens the normative authority of law, encourages informal responses to violence and compromises the State's ability to mediate conflicts in a legitimate way, and it is

expected to reflect that external control, when it ceases to fulfill its transformative function, becomes part of the very problem it should face, becoming part of an institutional mechanism that normalizes the exception and trivializes the violation of rights (Ávila, 2014; Padilha, 2020).

In view of this situation, overcoming the structural limits of the traditional model of external control requires a profound reconfiguration of institutional practices, guided by a substantive conception of effectiveness. Such a reconfiguration presupposes the strengthening of the informational autonomy of the Public Prosecutor's Office, the construction of integrated strategies of action, the investment in specialized technical capacities, and the adoption of a logic of control aimed at transforming structural patterns of police action (Corrêa; Coutinho, 2019).

The notion of effectiveness, in the context of the external control of police activity, requires a relevant conceptual shift, not limiting itself to assessing only the formal existence of procedures, ordinances, reports or recommendations issued by ministerial bodies, but to examine whether such instruments are capable of generating measurable institutional impacts, altering repeated patterns of police action and consistently reducing, abusive, illegal or incompatible practices with the Democratic Rule of Law, such as in cases that also involve human and international rights. Effectiveness, therefore, is close to the idea of the transformative capacity of institutional action, linked to the production of results and not to the mere ritualistic observance of normative competences (Camelo, 2025).

The external control of police activity, although constitutionally ensured, often becomes a model of low material density, marked by strong procedural adherence and reduced structural incidence, as a kind of phenomenon that manifests itself when the Public Prosecutor's Office limits its action to the formal monitoring of investigations, the issuance of official letters or *ex post* analysis of records produced by the police corporations themselves, without effective capacity to interfere in the logic of information production, in the definition of investigative lines or in the concrete accountability of the agents involved (Ávila, 2014; Basílio; Basílio, 2023).

Police activity, especially in cases of use of lethal force, is marked by significant informational asymmetry, in which the initial elements of factual reconstruction remain under the control of the investigated corporation itself. Occurrence records, preliminary reports, testimonial reports collected in the heat of the facts and initial expert reports are produced, as a rule, by agents belonging to the same hierarchical structure involved in the event, which compromises the impartiality and completeness of the information available to the control body (Pedrosa Júnior; Monteiro; Birth, 2023; Camelo, 2025).

It so happens that such dependence is not only a technical obstacle, but also a structural problem of governance, because when the external controller does not have autonomous means of producing evidence, immediate access to the scenes of the facts or independent technical teams, the control tends to operate in a reactive, late and fragmented manner. The direct consequence is the reduction of the Public Prosecutor's Office's ability to question official versions, identify narrative incongruities, or reconstruct events in a minimally reliable way, especially in contexts of police violence involving vulnerable populations (Fernandes, 2023).

Thus, the persistence of abusive practices without an adequate institutional response compromises the legitimacy of justice institutions, as already well discussed, and social trust in the ministerial body, the police and the Judiciary itself is gradually eroded when repeated episodes of violence do not result in a serious, transparent and independent investigation. Based on this assumption, the perception of institutional connivance, even if unintentional, weakens the democratic pact and feeds discourses of discredit in relation to the rule of law (Fernandes, 2023; Pedrosa Júnior; Monteiro; Nascimento, 2023).

From the perspective of International Human Rights Law, the ineffectiveness of external control takes on even more serious contours, which will be highlighted with greater attention in the following chapter, which will seek to discuss emblematic cases that had the support and action of the Public Prosecutor's Office in this regard.

International jurisprudence has repeatedly affirmed that the absence of diligent, independent and effective investigations in cases of police violence constitutes an autonomous violation of human rights, especially the right to life and judicial guarantees. It is based on the understanding that external control is not a political faculty of the State, but an internationally enforceable legal duty (Camelo, 2025).

Therefore, the effectiveness of external control depends on a broader institutional reconfiguration, and such reconfiguration involves the structural strengthening of the Public Prosecutor's Office, the creation of autonomous mechanisms for the production of information, the integration of databases, the adoption of results-oriented performance indicators, and the systematic incorporation of international standards of police accountability (Fernandes, 2023; Basílio; Basílio, 2023).

Without these transformations, external control tends to remain imprisoned in a formalistic logic, incapable of facing the structural challenges of police violence in Brazil, given that effectiveness is not presented as an automatic attribute of the constitutional provision, but as a continuous institutional construction, dependent on political choices, organizational

arrangements and normative commitments to democracy and human rights (Corrêa; Coutinho, 2019; Pine; Chaves; Miranda, 2024).

In this line, a denser reflection on the role of the Public Prosecutor's Office in the contemporary constitutional system is proposed, since, more than a reactive supervisory body, the Public Prosecutor's Office is called upon to act as a guarantor institution, capable of articulating control, prevention and institutional transformation. The effectiveness of external control, therefore, becomes a central element for the legitimacy of the justice system itself and for the consolidation of a public security model compatible with constitutional values.

The permanence of ineffective external control is not neutral, producing concrete effects on lives, territories and social trajectories, feeding cycles of violence and exclusion. Recognizing these structural limits does not mean delegitimizing the ministerial function, but rather highlighting the urgency of its improvement, under penalty of external control remaining as a normative promise not fulfilled within the Democratic State of Law.

4 THE INTER-AMERICAN HUMAN RIGHTS SYSTEM AS AN EVALUATION PARAMETER: THE NOVA BRASÍLIA FAVELA CASE VS. BRAZIL (ADPF NO. 635/RJ)

The examination and discussion of the external control of police activity, when it is moved beyond the strictly internal normative plane, requires the incorporation of international parameters for the protection of human rights as hermeneutic and evaluative instruments of state action. In view of this premise, the Inter-American Human Rights System is central, not limited to a subsidiary instance of international accountability and being a true space for the construction of structural standards of democratic legality, capable of bringing to light possible persistent systemic flaws in the national models of public security and criminal prosecution.

The jurisprudence of the Inter-American Court of Human Rights, over the last decades, has played a decisive role in identifying repeated patterns of state violence, investigative insufficiency, and the absence of independent control mechanisms, especially in countries marked by authoritarian legacies and deep structural inequalities, as is the case in Brazil (Camelo, 2025).

It is considered that the incorporation of these parameters is not limited to a formal commitment assumed by the Brazilian State when ratifying international treaties, since it projects direct effects on the interpretation of the constitutional and infra-constitutional norms that govern the performance of justice institutions.

In this vein, the external control of police activity, constitutionally attributed to the Public Prosecutor's Office, must be understood in the light of international obligations to prevent,

investigate, punish, and repair human rights violations, under penalty of perpetuating a merely symbolic accountability model, incapable of facing the complexity of the violations recognized at the inter-American level (Camelo, 2025).

The condemnations imposed on Brazil by the Inter-American Court of Human Rights in cases involving police violence, extrajudicial executions, torture and investigative failures reveal the existence of structural patterns of state ineffectiveness that transcend isolated episodes. Paradigmatic cases such as *Favela Nova Brasília vs. Brazil*, *Ximenes Lopes vs. Brazil* and the *Araguaia Guerrilla vs. In Brazil*, they show not only the occurrence of serious violations of fundamental rights, but, above all, the persistent inability of the State to conduct independent, swift and effective investigations, capable of breaking cycles of institutionalized impunity (IACHR Court, 2017).

That said, as an element and jurisprudential understanding relevant to the present discussion, there is the case "*Favela Nova Brasília vs Brazil*", in which the Court recognized that violent police action, associated with the absence of impartial investigations and the systematic archiving of procedures, configured a structural practice of state tolerance to police lethality in territories marked by social vulnerability. Being a decision that has exposed the dependence of investigations on the police corporations involved in the facts, it compromises the impartiality and credibility of the investigative process, reinforcing the need for external and autonomous control and inspection mechanisms (IACHR, 2017; Vieira, 2025).

This international pronouncement dialogues directly with the doctrinal criticism of the fragmentation and fragility of external control in Brazil, and it is possible to point out that the performance of the Public Prosecutor's Office, although constitutionally robust, is still limited by structural obstacles, such as the informational dependence on the police, the scarcity of specialized teams and the absence of standardized protocols for investigating serious human rights violations (Ávila, 2014; Vieira, 2025). Such limitations favor the reproduction of a model of selective accountability, in which state violence remains, to a large extent, invisible or naturalized.

The Inter-American Court has reiterated that the obligation to investigate is not satisfied with the formal initiation of proceedings, but requires concrete results capable of identifying individual and institutional responsibilities. The absence of such results, as pointed out in several decisions, constitutes in itself an autonomous violation of the rights enshrined in the American Convention, especially the right to judicial protection and judicial guarantees (Camelo, 2025).

This understanding broadens the concept of effectiveness, shifting it from the procedural to the substantial level, in which state action is evaluated based on its real impacts on the protection of human dignity. In the Brazilian context, international condemnations also show the persistence of an institutional culture marked by distrust of human rights, often perceived as obstacles to police efficiency, and it is essential to verify that this logic, inherited from authoritarian periods, contributes negatively to the trivialization of violence and to the legitimization of practices incompatible with the Democratic Rule of Law. disproportionately affecting black, peripheral, and historically marginalized populations (Macedo Júnior, 2019).

The structural dimension of state failures is also manifested in the racial and territorial selectivity of police violence, an element widely recognized in inter-American decisions. The Inter-American Court of Human Rights has highlighted that the disproportionate incidence of police lethality against young black people and residents of the peripheries cannot be dissociated from historical patterns of discrimination and marginalization, and the absence of effective investigations in these cases reinforces the idea that certain lives are less protected by law, which constitutes a violation of the principle of equality and the prohibition of discrimination enshrined in the American Convention (Camelo, 2025; Vieira, 2025).

Therefore, international condemnations function as a critical mirror of the internal justice system, revealing the inability of the Brazilian State to break with deep-rooted institutional practices, where the repetition of similar violations over time indicates the existence of structural flaws, demanding responses that go beyond individual accountability and achieve profound institutional reforms (Basilio; Basilio, 2023).

According to Basilio and Basilio (2023), the IACHR, in judging the case, came to the conclusion that the Brazilian State had international responsibilities for several human rights violations, such as those shown in Table 1, below, for a better view:

Table 1

Violations recognized within the inter-American system

Breached Devices	International instrument	Type of violation	Group of victims
Art. 4.1 c/c art. 1.1	American Convention on Human Rights	Violation of the right to life by excessive use of police force	Adult victims of lethal police operations
Arts. 4.1 and 19 c/c art. 1.1	American Convention on Human Rights	Violation of the right to life of children and adolescents	Victims of sexual violence by state agents
Arts. 5.2 and 11 c/c art. 1.1	American Convention on Human Rights	Torture, sexual violence and violation of personal integrity	Victims of sexual violence by state agents
Arts. 5.1, 8.1 and 25.1 c/c art. 1.1	American Convention on Human Rights	Investigative failures and absence of	Direct victims and family members

		effective judicial protection	
Art. 7	Convention of Belém do Pará	Gender-based violence	Women and girls

Source: Prepared by the author, based on Basilio and Basilio (2023).

The recommendations after the entire investigative phase and judgment before the Inter-American System, also according to Basilio and Basilio (2023), were within the scope of the need to improve investigations, and should be independently, impartial, effective, unrelated to politics, once again reinforcing the essentiality of the external control defended and unraveled so far. Other points raised refer to reparation through full compensation for material damage to victims and relatives, greater transparency with the end of the automatic registration of deaths as "resistance to arrest", accountability through the creation and strengthening of internal and external controls with a gender and race perspective, as well as institutional reform as a whole, for the modernization, professionalization and accountability of the police forces, also having, specifically, the regulation of the use of force as a last resort, according to principles of necessity and proportionality.

The lack of strengthening of external control of police activity, in this scenario, emerges as one of the main factors in maintaining these failures, since the body constitutionally charged with exercising this control does not have, in many cases, the material and institutional conditions to do so fully (Camelo, 2025).

The Court's decisions also highlight the importance of the participation of victims and their families in the investigative processes, as an essential element for the effectiveness of the investigation. However, in Brazil, state action is often characterized by the exclusion of victims from the investigative process, limiting their access to information and restricting their ability to question official versions. This practice contributes to institutional opacity and reinforces the asymmetry of power between the State and citizens affected by police violence, deepening the democratic deficit of the justice system (Vieira, 2025).

The persistence of ineffective investigations, the informational dependence of the police, the fragmentation of external control and the absence of consistent preventive policies make up a complex picture of state failures that feed back on each other and, under this scope, the external control of police activity assumes centrality as an instrument capable of breaking with this logic, as long as it is endowed with autonomy, resources and strategic orientation compatible with international human rights standards.

The Federal Supreme Court also expressed itself on the aforementioned case, through the Allegation of Non-Compliance with a Fundamental Precept No. 635/RJ, which is consolidated as one of the most relevant jurisprudential frameworks of contemporary Brazilian

constitutionalism with regard to the articulation between public security policy, external control of police activity and structural protection of fundamental rights, going so far as to expressly recognize the existence of a chronic picture of human rights violations resulting from police lethality, highlighted in the Summary, associated with a structural omission by the Government in the adoption of effective prevention, investigation and accountability measures, shifting the debate from the merely episodic level to an institutional and systemic approach (Supreme Federal Court, 2025).

It is based on the recognition that the high police lethality in the State of Rio de Janeiro does not objectively represent a historical pattern of action, marked by the normalization of the excessive use of lethal force, the fragility of accountability mechanisms, and the reproduction of administrative and investigative practices that favor impunity (Supreme Federal Court, 2025).

Now, such elucidation is fundamental to understand the role attributed to the Public Prosecutor's Office in the trial, since the external control of police activity is now conceived not only as a formal attribution provided for in Article 129, VII, of the Constitution, but as a structuring instrument of the democratic constitutional order itself.

Furthermore, the Supreme Court explains that external control is not to be confused with undue interference in police activity or with the replacement of the administrative functions of corporations, but constitutes an institutional guarantee aimed at the protection of the civilian population and the security agents themselves, moving away from corporatist or defensive readings of the constitutional model, criticizing the large bureaucracy in Brazil that governs such oversight of police activities (Supreme Court Federal, 2025).

By stating that there is no necessary antagonism between police efficiency and respect for fundamental rights, the Court breaks with the binary logic that has historically opposed public security and human rights, reaffirming that the legitimacy of police action depends, precisely, on the strict observance of the constitutional principles of legality, proportionality and necessity, and there is, therefore, "[...] opportunity for institutional maturation and improvement of police activity, and its external control, based on the principles of transparency, democratic participation and accountability" (Supreme Federal Court, 2025, p. 4).

The decision also highlights that police lethality does not produce a relevant deterrent effect in reducing crime, based on relevant data presented in the records that demonstrate the coexistence between high rates of deaths resulting from police intervention and the persistence of structural violence (Supreme Federal Court, 2025), which is especially relevant for the external control exercised by the Public Prosecutor's Office, because it shifts the focus of

institutional action from the simple formal monitoring of operations to the critical evaluation of their real impacts, requiring action guided by evidence, data and verifiable results.

It is important to report after analysis of the judgment that, by partially approving the plan to reduce police lethality presented by the State of Rio de Janeiro, the Federal Supreme Court establishes a model of dialogical jurisdictional control, in which the Judiciary recognizes institutional advances, but imposes complementary determinations aimed at correcting persistent deficits (Supreme Federal Court, 2025).

Among these determinations, the centrality given to the external control function of the Public Prosecutor's Office stands out, especially with regard to the production of detailed reports at the end of each police operation, the requirement to share georeferenced data and microdata, and the standardization of investigation protocols (Supremo Tribunal Federal, 2025).

The requirement for subsequent accountability of police operations, with technical and legal details of the grounds for the action, represents a significant inflection in relation to historical practices marked by opacity and administrative self-legitimation. On this point, the Court explains that the accountability of police activity is not a mere bureaucratic formality, but a condition for the democratic legitimacy of state action, directly linked to the principles of publicity, efficiency, and administrative morality provided for in Article 37 of the Constitution (Supreme Federal Court, 2025, p. 27).

The investigative competence of the Public Prosecutor's Office in cases of suspected involvement of security agents in intentional crimes against life is unequivocally reaffirmed, qualifying this action as a true institutional power-duty, being one of the measures mentioned so that new attitudes on the part of the police forces can be built, even if gradually, striving for the principle that governs accountability. In this case, of their accountability, as in the adaptation and realization of "[...] communications and reports, especially addressed to the Public Prosecutor's Office, a body entrusted by the Constitution with the power-duty to investigate and denounce possible abuses" (Supreme Federal Court, 2025, p. 93). By rejecting the understanding that direct investigation by the Public Prosecutor's Office would be a discretionary power, the Federal Supreme Court establishes the guarantor dimension of external control, linking it to the need for functional independence and technical autonomy, in line with the international standards established by the United Nations Principles on the Use of Force and Firearms.

Another aspect of high constitutional density lies in the determination of strict preservation of the traces of crimes that occurred in police operations, with prohibition on the improper removal of corpses under the pretext of help and the requirement of detailed expert

documentation, as measures that dialogue directly with the history of violations recognized by the Inter-American Court of Human Rights in the Favela Nova Brasília case. incorporating into Brazilian domestic law a conventionalized reading of the state's duty to investigate diligently, impartially, and effectively (Supreme Federal Court, 2025).

On the symbolic and normative level, ADPF 635/RJ thus projects a conception of the Public Prosecutor's Office as an external institution of guarantee, whose legitimacy derives not only from its constitutional provision, but from its effective capacity to intervene in contexts of structural violence, racial inequality, and criminal selectivity.

By requiring that external control be exercised from a gender, ethnic-racial, and territorial perspective, this Court recognizes that police lethality disproportionately affects historically marginalized populations, imposing on the Public Prosecutor's Office the duty to act sensitive to the social asymmetries that cross the criminal justice system (Supreme Federal Court, 2025).

The reduction of police lethality is not a political concession or discretionary administrative choice, being, therefore, a constitutional and conventional imperative, directly linked to the protection of the right to life, personal integrity and access to justice, with an important contribution to the external control of police activity as a structuring axis of the effectiveness of fundamental rights, requiring from the Public Prosecutor's Office not only formal vigilance, but institutional protagonism, technical capacity and continuous democratic commitment to the transformation of public security practices in the light of the 1988 Constitution.

Based on everything discussed so far, Brazil's condemnations within the scope of the Inter-American System should not be understood only as external sanctions, but as qualified diagnoses of the limits of the internal model of control and accountability, such as the case "Favela Nova Brasília vs Brazil", as they bring to light that the effectiveness of external control is not merely an administrative matter. but an essential requirement for the protection of fundamental rights and for the consolidation of the Democratic Rule of Law.

The inability to address these structural flaws keeps the country in a cycle of repeated violations, compromising its international legitimacy and, above all, its internal capacity to ensure justice and dignity for all citizens.

5 CONCLUSION

The external control of police activity, as provided for in the 1988 constitutional design, is, in fact, a structuring element of the Democratic Rule of Law, and cannot be reduced to a merely formal or accessory attribution of the Public Prosecutor's Office, as it represents a

function endowed with its own normative density, directly linked to the protection of fundamental rights, the limitation of state coercive power and the preservation of the democratic legitimacy of justice institutions.

The Federal Constitution, by expressly attributing to the Public Prosecutor's Office the exercise of external control of police activity, recognized that the action of the armed apparatuses of the State requires permanent, independent and qualified inspection, due to the direct and immediate impact it produces on the freedom, integrity and life of people, as a constitutional choice broke with self-referential models of public security and inserted police activity in a broader system of checks and balances counterweights, in which legality, proportionality and accountability do not present themselves as obstacles to efficiency, but as conditions of their legitimacy.

However, the critical investigation undertaken demonstrated that, despite the normative robustness of the constitutional model, the external control of police activity faces significant structural limits that compromise its material effectiveness. The informational dependence on police corporations, the fragmentation of control initiatives, the insufficiency of specialized technical resources and the excessive bureaucratization of institutional practices contribute to the consolidation of a model of low transformative incidence, incapable of confronting structural patterns of violence and criminal selectivity.

That said, the effectiveness of external control cannot be measured by the mere existence of formal procedures, reports or recommendations issued, but by the concrete capacity to produce verifiable institutional results, capable of changing repeated practices, preventing abuses and inducing structural changes in police action, where the absence of these results deepens the social perception of impunity, weakens trust in justice institutions and erodes the foundations materials of the Democratic Rule of Law.

The incorporation of the parameters of the Inter-American Human Rights System is also essential for understanding these structural flaws. The convictions imposed on Brazil, especially in the case of *Favela Nova Brasília v. Brazil*, show that the ineffectiveness of the investigations and the absence of independent control mechanisms constitute autonomous violations of human rights, projecting international responsibilities to the State, functioning as a qualified diagnosis of persistent systemic problems, which cannot be faced by punctual or symbolic responses.

The jurisprudence of the Inter-American Court reinforces the idea that the duty to investigate is not satisfied with the formal initiation of proceedings, requiring diligence, independence, impartiality, and concrete results. Thus, the external control of police activity

assumes the nature of a legal obligation, both domestic and international, and is inseparable from the state's duty to prevent, investigate, punish and repair violations of fundamental rights.

At the domestic level, ADPF 635/RJ has consolidated itself as a decision-making framework of high constitutional density by recognizing the existence of a structural framework of police lethality and by attributing centrality to the role of the Public Prosecutor's Office in the adoption of control, transparency and accountability measures. It so happens that the decision of the Federal Supreme Court shifted the debate from the episodic level to a structural approach, reaffirming that the reduction of police lethality is a constitutional and conventional imperative, and not a mere discretionary administrative option.

By requiring the production of data, reports, standardized protocols, and evidence-based accountability mechanisms, the Supreme Court conferred concrete normative content to the function of external control, reinforcing its guarantor dimension and its direct link to the protection of the right to life, personal integrity, and access to justice. In this context, the Public Prosecutor's Office is called upon to act not only as a formal inspector, but as an external guarantee institution, endowed with institutional protagonism and democratic commitment to the transformation of public security practices.

It is understood, therefore, that overcoming the structural limits of external control of police activity requires a profound reconfiguration of institutional practices, guided by a substantive conception of effectiveness, and such reconfiguration involves strengthening the informational autonomy of the Public Prosecutor's Office, integrating action strategies, investing in specialized technical capacities, and systematically incorporating international standards of law humans.

Finally, it is reaffirmed that the strengthening of external control of police activity is not only in the interest of the Public Prosecutor's Office or the justice institutions, but of society as a whole, insofar as it is an indispensable requirement for the consolidation of a public security model compatible with the constitutional and conventional values assumed by the Brazilian State. The effectiveness of this control represents, ultimately, the concrete affirmation of the Democratic Rule of Law and the centrality of fundamental rights in the organization of social life.

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OUTSOURCING EMOTIONAL REGULATION: THE USE OF SMARTPHONES AND THE WEAKENING OF HUMAN MEDIATION

A TERCEIRIZAÇÃO DA REGULAÇÃO EMOCIONAL: O USO DE SMARTPHONES E A FRAGILIZAÇÃO DA MEDIAÇÃO HUMANA

LA SUBCONTRATACIÓN DE LA REGULACIÓN EMOCIONAL: EL USO DE LOS TELÉFONOS INTELIGENTES Y EL DEBILITAMIENTO DE LA MEDIACIÓN HUMANA



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ABSTRACT

This article analyzes digital dependence in contemporary culture from the perspective of its articulation with emotional regulation processes, with an emphasis on the outsourcing of these functions to smartphones. It starts from the premise that, in the age of hyperconnectivity, these devices have been incorporated as mediators of emotional experience, playing regulatory roles in the face of negative affective states. In this context, their use is configured as a coping strategy, highlighting the displacement of emotional mediation from human interactions to digital environments. The objective is to understand the impacts of this pattern on mental health, social relations, and educational processes, paying attention to the weakening of human mediation and the vulnerability of children and adolescents. Methodologically, this is an analytical bibliographic research, based on a critical review of the literature and the analysis of normative frameworks, with emphasis on the Digital Statute of Children and Adolescents (Law No. 15.211/2025). The results indicate harm to cognitive, emotional, and social development, as well as impairment of family interactions. It is concluded that digital addiction is a multifactorial phenomenon that requires the integration of psychological, sociocultural, and normative dimensions, with qualified mediation being

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central to a balanced relationship with digital technologies. The development of educational practices that promote the critical and conscious use of digital technologies is recommended.

Keywords: Digital Addiction. Emotional Regulation. Smartphones. Educational Mediation. Hyperconnectivity.

RESUMO

Este artigo analisa a dependência digital na cultura contemporânea a partir de sua articulação com processos de regulação emocional, com ênfase na terceirização dessas funções para smartphones. Parte-se do pressuposto de que, na era da hiperconectividade, esses dispositivos têm sido incorporados como mediadores da experiência emocional, desempenhando funções regulatórias diante de estados afetivos negativos. Nesse contexto, seu uso configura-se como estratégia de enfrentamento, evidenciando o deslocamento da mediação emocional das interações humanas para ambientes digitais. O objetivo é compreender os impactos desse padrão na saúde mental, nas relações sociais e nos processos educativos, com atenção à fragilização da mediação humana e à vulnerabilidade de crianças e adolescentes. Metodologicamente, trata-se de pesquisa bibliográfica analítica, baseada na revisão crítica da literatura e na análise de marcos normativos, com destaque para o Estatuto Digital da Criança e do Adolescente (Lei nº 15.211/2025). Os resultados indicam prejuízos ao desenvolvimento cognitivo, emocional e social, além do comprometimento das interações familiares. Conclui-se que a dependência digital é fenômeno multifatorial que exige integração de dimensões psicológicas, socioculturais e normativas, sendo a mediação qualificada central para uma relação equilibrada com as tecnologias digitais. Recomenda-se o desenvolvimento de práticas educativas que promovam uso crítico e consciente das tecnologias digitais.

Palavras-chave: Dependência Digital. Regulação Emocional. Smartphones. Mediação Educativa. Hiperconectividade.

RESUMEN

Este artículo analiza la dependencia digital en la cultura contemporánea desde la perspectiva de su articulación con los procesos de regulación emocional, con énfasis en la externalización de estas funciones a los teléfonos inteligentes. Parte de la premisa de que, en la era de la hiperconectividad, estos dispositivos se han incorporado como mediadores de la experiencia emocional, desempeñando roles reguladores ante estados afectivos negativos. En este contexto, su uso se configura como una estrategia de afrontamiento, lo que resalta el desplazamiento de la mediación emocional de las interacciones humanas a los entornos digitales. El objetivo es comprender los impactos de este patrón en la salud mental, las relaciones sociales y los procesos educativos, prestando atención al debilitamiento de la mediación humana y la vulnerabilidad de niños y adolescentes. Metodológicamente, se trata de una investigación bibliográfica analítica, basada en una revisión crítica de la literatura y el análisis de marcos normativos, con énfasis en el Estatuto Digital de Niños y Adolescentes (Ley n.º 15.211/2025). Los resultados indican daños al desarrollo cognitivo, emocional y social, así como un deterioro de las interacciones familiares. Se concluye que la adicción digital es un fenómeno multifactorial que requiere la integración de dimensiones psicológicas, socioculturales y normativas, siendo la mediación cualificada fundamental para una relación equilibrada con las tecnologías digitales. Se recomienda el desarrollo de prácticas educativas que promuevan el uso crítico y consciente de las tecnologías digitales.

Palabras clave: Adicción Digital. Regulación Emocional. Smartphones. Mediación Educativa. Hiperconectividad.

1 INTRODUCTION

The intensification of the use of smartphones and other digital technologies has promoted significant transformations in the forms of social interaction, daily habits, and emotional regulation processes. In this context, nomophobia stands out, characterized by the fear of being without access to a cell phone, a phenomenon associated with an increase in symptoms of anxiety and depression (ELHAI; DVOŘÁK; HALL, 2020).

In contemporary digital culture, digital technologies, particularly smartphones, are not limited to the expansion of instrumental capacities, but operate as structuring devices that reconfigure modes of perception, cognitive processes, and forms of constitution of subjectivity. By continuously mediating everyday experience, these technological artifacts begin to influence not only access to information, but also the way individuals interpret the world, organize attention, and construct meanings about themselves and others, evidencing their centrality in the reorganization of sociocultural and psychic dynamics in contemporary times (SANTAELLA, 2020).

From this perspective, the growing mobilization of smartphones as emotional regulation devices is observed, especially in the face of negative affective states, such as anxiety, boredom and frustration. This movement indicates that such technologies cease to perform a merely instrumental function and start to act as mediators of coping processes, being incorporated as immediate responses to emotional demands. As a result, there is a progressive shift from traditional regulation mechanisms, historically anchored in human interactions, to strategies mediated by digital devices, reconfiguring the ways of dealing with the affective experience in contemporary times (NICOLACI-DA-COSTA, 2006).

This study, situated in the field of human and social sciences, aims to analyze digital dependence from its articulation with emotional regulation processes, with emphasis on the outsourcing of these functions to smartphones. It seeks to understand the role of these devices, in the context of nomophobia, as coping strategies, as well as their impacts on mental health, social relationships and the weakening of human mediation, especially among children and adolescents. Its relevance stems from the advancement of the effects of technology on mental health, as well as the growing need for regulation in the digital environment, expressed, in Brazil, by Law No. 15,211/2025.

Methodologically, this is a bibliographic research based on a critical review of the literature. The article is structured in three axes: fundamentals of digital dependence, analysis of the use of smartphones as a strategy for emotional regulation and discussion of its psychological and social impacts. It is based on the hypothesis that the incorporation of digital

devices as mediators of emotional experience configures a process of outsourcing emotional regulation, with direct implications in the weakening of human mediation and in the reorganization of social bonds in contemporary times.

2 THEORETICAL FOUNDATION

Digital addiction, also called problematic use of digital technologies, especially smartphones, is configured as a multifactorial phenomenon located at the intersection between socio-technical transformations and subjective processes. It is a persistent pattern of use characterized not only by frequency or intensity, but above all by its psychological function, producing impairments in emotional functioning, social relationships, academic performance and quality of life (BUSCH; MCCARTHY, 2021; MONTAG; WALLA, 2021).

In this sense, digital addiction can be understood as a form of maladaptive emotional regulation, in which smartphones and other digital devices are mobilized as coping strategies in the face of negative affective states.

The scientific literature has consistently shown the association between the intensive use of mobile devices, especially smartphones, and a decrease in subjective well-being, accompanied by an increase in symptoms of anxiety, stress, and dissatisfaction. This body of evidence suggests that such impacts are not restricted to the frequency of use, but are related to the functions that these devices assume in daily life, particularly when mobilized as strategies for emotional regulation and immediate response to affective demands, contributing to the intensification of patterns of dependence and psychological vulnerability (ELHAI; DVOŘÁK; HALL, 2020).

However, this relationship should not be interpreted exclusively in quantitative terms, as a simple excess of time of use, but in the light of the structural, cultural and psychological conditions that sustain the centrality of technologies in contemporary daily life.

Thus, the analytical focus shifts from how much is used to why and how it is used, highlighting the role of smartphones as central mediators of emotional experience. On the sociotechnical level, hyperconnectivity emerges as a structuring element of contemporary social life, characterized by permanent connectivity that redefines the forms of interaction and establishes continuous availability as a social norm (CASTELLS, 2015; VAN DIJCK, 2013).

This phenomenon is integrated into the cultures of connectivity, which operate as normative devices, guiding practices, expectations, and forms of engagement in the digital environment. Constant presence on the networks is no longer a choice and becomes a

sociocultural requirement, producing a scenario in which disconnection can generate anxiety, discomfort and a feeling of exclusion.

Among the factors that support this pattern, the fear of missing out (FOMO), digital multitasking, and the internalization of continuous connection habits stand out. FOMO, in particular, acts as an important psychological mechanism, by producing a persistent sense of incompleteness and urgency, leading individuals to turn to digital devices as a form of immediate emotional regulation (PRZYBYLSKI et al., 2013).

Such practices are not homogeneous, being modulated by sociocultural factors, so that family, educational and institutional contexts can both intensify and mitigate patterns of problematic use.

The understanding of this phenomenon is deepened in the light of the Theory of Self-Determination, which postulates that human behavior is guided by the continuous search for satisfaction of basic psychological needs, such as autonomy, competence and belonging. In this context, such needs constitute essential foundations for healthy development and well-being, so that their frustration tends to trigger compensatory strategies of emotional regulation, often mediated by digital devices, which contributes to the consolidation of problematic use patterns (RYAN; DECI, 2017).

In this context, the use of digital technologies can assume an adaptive character when it contributes to the fulfillment of these needs, or maladaptive when it starts to operate as a compensatory strategy in the face of their frustration. Thus, the use of smartphones as an emotional regulation strategy can be understood as a response to deficits in the conditions for satisfying these needs, configuring itself as a coping mechanism that, although functional in the short term, tends to produce negative effects on psychological development and social relationships over time (RYAN; DECI, 2017).

In this sense, digital dependence should not be reduced to deviant individual behavior, but understood as an expression of a broader socio-technical ecology, in which technologies, social structures, and subjective processes are articulated in the production of new forms of emotional regulation. Such a perspective requires analytical approaches that integrate psychological, cultural, and normative dimensions, especially in the face of the advancement of regulatory frameworks that recognize the impacts of the digital environment on human development.

2.1 CONCEPTS OF DIGITAL DEPENDENCE

Digital dependence is epistemologically consolidated as a persistent and profoundly unregulated behavioral pattern in the consumption of technologies, culminating in acute psychic suffering or systemic functional impairments in the multiple spheres of the subject's life. In contrast to restrictive methodological approaches, this construct transcends the mere fixation on specific platforms, also encompassing engagement in daily practices of neutral appearance, such as the obsessive checking of messages and notifications, whose volume and functionality denounce the automation of habit and the failure of self-regulation mechanisms (BUSCH; MCCARTHY, 2021; MONTAG; WALLA, 2021).

From an analytical perspective, the phenomenon is aligned with the taxonomy of behavioral dependencies, being diagnosed by the presence of clinical markers such as tolerance, withdrawal syndrome, collapse of inhibitory control, and perpetuation of use despite deleterious externalities. In this scenario, the instrumentalization of technology as a *coping strategy stands out*, in which the digital apparatus is phagocytosed as a way to access instant gratification or as a shield against aversive affective states, such as anxiety, boredom and loneliness (RYAN; DECI, 2017; ELHAI; DVOŘÁK; HALL, 2020).

Consequently, interaction with smartphones and application ecosystems is detached from its purely instrumental purpose to assume a central regulatory function, operating as the main prosthesis for mediating emotional states.

In view of this framework, there is a rigorous need to delineate the epistemological boundary between quantitatively frequent and qualitatively problematic use. Intensive immersion, in isolation, does not typify dependence, since the diagnosis requires the unequivocal verification of the loss of agency, the obsessive centrality of the behavior in the subject's routine and the outbreak of latent structural damage (MONTAG; WALLA, 2021).

It is evident, therefore, that the measurement of digital dependence does not tolerate reductionism centered strictly on screen time, demanding an exegesis based on its psychological functionality, notably with regard to the capture of smartphones as vectors of maladaptive emotional regulation.

Empirical incursions dedicated to the phenomenon have mobilized a diversified methodological arsenal, encompassing validated psychometric scales, behavioral screening, and the measurement of mental health markers. The scrutiny of these data reveals a robust convergence indicating that high rates of digital dependence are unmistakably linked to the corrosion of subjective well-being and the proliferation of psychiatric symptoms, with the

consumption of social networks as one of the most striking predictors of this deterioration (ELHAI; DVOŘÁK; HALL, 2020; PRZYBYLSKI et al., 2013).

Such evidence consolidates the premise that the problematic use of sociotechnical arrangements is umbilically intertwined with processes of frankly maladaptive emotional regulation, in which the incessant hunt for ephemeral psychic relief culminates in the severe impairment of psychological homeostasis in the medium and long term.

2.2 HYPERCONNECTIVITY AND CONNECTIVITY CULTURES

Hyperconnectivity is erected as one of the ontological pillars of contemporaneity, transcending the mere technical infrastructure to consolidate itself as a pervasive integration of subjects into digital networks. This phenomenon is characterized by the intensification of mediated sociabilities, configuring a sociocultural condition that reorients the coordinates of time, attention and presence. Under this aegis, permanent connectivity ceases to be a contingency to become a structuring norm, redefining the grammars of social interaction (CASTELLS, 2015; VAN DIJCK, 2013).

In this scenario, uninterrupted availability is stripped of its elective character and begins to operate as an implicit imperative, engendering new regimes of engagement and exogenous modalities of social pressure. The so-called "cultures of connectivity" act, therefore, as normative devices that guide behaviors, expectations, and subjectivities in the digital ecosystem. Such devices institutionalize tacit patterns about the frequency and nature of being connected, naturalizing omnipresence on networks by linking it to symbolic capitals of belonging, visibility, and social validation. Consequently, practices such as digital multitasking and reactive surveillance of notifications are internalized not only as habits, but as prerogatives for the maintenance of intersubjective recognition (VAN DIJCK, 2013; CASTELLS, 2015).

Among the psychosocial constructs that sustain this dynamic, the *fear of missing out* (FOMO) stands out — the persistent and diffuse apprehension that potentially rewarding experiences of others are occurring without the subject's knowledge. This phenomenon precipitates a state of chronic urgency and ontological incompleteness, compelling individuals to a digital hypervigilance in which mobile devices start to act as prostheses of immediate emotional regulation (PRZYBYLSKI et al., 2013).

From this perspective, hyperconnectivity not only circumscribes social practices, but also organizes affective economies, reinforcing the dependence on informational flows for the stabilization of internal states.

Simultaneously, the sociocultural ecosystem exerts a determining influence on the vectors of use of technologies, outlining factors of vulnerability and resilience. Cohesive family environments, face-to-face interactions endowed with symbolic density, and robust emotional support systems operate as protective instances, enabling a relationship of agency and balance with the digital. On the other hand, scenarios marked by bonding weaknesses, lack of symbolic mediation, and unprocessed affective demands tend to catalyze the use of technologies as compensatory mechanisms for coping with and regulating affects (LEMOS, 2021; RYAN; DECI, 2017).

Teleological analysis of the use of digital technologies demonstrates that the underlying motivations determine the impact of digital on subjective well-being. While the use of expressiveness and dialogic communication tends to foster positive experiences, the use driven by normative pressures, the need for external validation, or emotional avoidance schemes has a high deleterious potential. This differentiation underlines that pathogenicity does not reside in technology *per se*, but in the psychic function it assumes in the subject's economy, reiterating the urgency of investigating the qualitative dimension of digital use, especially in its interface as a strategy of emotional regulation.

2.3 PSYCHOLOGY OF TECHNOLOGICAL DEPENDENCE

The psychology of technological dependence offers a robust theoretical framework for understanding the mechanisms underlying the problematic use of digital technologies, allowing us to analyze it not only as excessive behavior, but as a process of emotional regulation mediated by technological systems. Among the explanatory models, the reinforcement theory stands out, according to which behaviors followed by rewards tend to be reiterated (AINSLIE, 2001; ALTER, 2017).

In the digital environment, this dynamic is intensified by systems structured based on intermittent reinforcements, such as notifications, likes, and messages, which enhance the maintenance of continuous engagement and make it difficult to interrupt use. In addition, cognitive approaches, such as the time preference theory, contribute to explain the human tendency to privilege immediate rewards over long-term benefits (AINSLIE, 2001).

Such predisposition favors the consolidation of patterns of compulsive use, since digital devices offer quick and accessible responses to the regulation of affective states, even when associated with progressive impairments in psychological functioning. From a neuropsychological point of view, the intensive use of smartphones and digital platforms is associated with the activation of brain reward systems, particularly the release of dopamine, a

central neurotransmitter in the processes of motivation, learning, and habit formation (MONTAG; WALLA, 2021).

Continuous exposure to highly responsive digital stimuli can lead to desensitization processes, requiring increasing levels of stimulation to obtain similar effects, which contributes to the escalation of use and the loss of behavioral control. At the same time, the absence of these stimuli can trigger stress responses, associated with the release of cortisol, configuring a cycle that articulates the search for pleasure with the avoidance of psychic discomfort. In this configuration, digital devices begin to operate as strategies for immediate emotional regulation, albeit of a transitory and potentially maladaptive nature, being mobilized in the face of states such as anxiety, boredom and loneliness (RYAN; DECI, 2017).

The consequences of this process are widely documented in the literature, including reduced attention span, impaired self-control, mood swings, sleep disturbances, and increased feelings of social isolation. Such evidence indicates that digital addiction should not be understood as an isolated phenomenon, but as an expression of a complex socio-technical ecology, in which technologies, cultural structures, and subjective processes are articulated in the production of new forms of emotional regulation (SANTAELLA, 2020).

In view of this socio-technical configuration, the enactment of Law No. 15,211/2025, which establishes the Digital Statute of Children and Adolescents, represents a relevant milestone in recognizing that the architecture of digital environments and their engagement mechanisms are not neutral and can directly interfere in the processes of cognitive, emotional, and social development (BRASIL, 2025).

By establishing full protection in the digital environment and co-responsibility between family, school, State, and technological platforms, the legislation shows that the processes of emotional regulation mediated by digital devices cannot be understood only as individual choices, but must be analyzed in the light of their structural conditions and their impacts on human development.

3 FAMILY MEDIATION AND DIGITAL REGULATION: IMPLICATIONS FOR DEVELOPMENT AND THE FORMATION OF VALUES

The delegation, by families, of emotional and behavioral mediation functions to smartphones and other digital devices is one of the most emblematic phenomena of the contemporary reconfiguration of educational practices in the sphere of private life. In this context, the consolidation of technological devices as substitute mediators of emotional regulation is observed, evidencing a significant shift in the forms of care and socialization. What

was traditionally carried out through presence, listening, dialogue and symbolic mediation is, in many cases, transferred to smartphones and other technologies that operate as immediate emotional support, reducing the centrality of human mediation in the formative processes (BAUMAN, 2001; ALVES, 2025a).

This configuration can be understood in the light of the transformations in the forms of interaction mediated by technology, in which permanent connectivity tends to reconfigure social bonds, making them more fluid, immediate, and sometimes less profound (BAUMAN, 2001). In a complementary way, Alves (2025a) highlights that the intensive use of digital devices in the educational and family context can compromise emotional and social development processes, especially when these devices assume regulatory functions that should be exercised in the context of human relationships.

Such a process reveals a transformation in family dynamics, in which the device ceases to be just a tool and starts to operate as an affective mediator, reorganizing both the childhood experience and the family's own educational function. This transformation can also be understood from Han's (2017) critique, which indicates that contemporary society, marked by the logic of performance and hyperstimulation, tends to weaken experiences of interiority, reflection, and bonding, favoring immediate and superficial responses to emotional states.

In this scenario, the use of smartphones as a strategy for emotional regulation can be interpreted as a response to the acceleration of daily life and the growing difficulty of sustaining relationships based on presence and listening. In the educational field, Alves (2025a) recognizes that digital technologies have significant potential for learning, expanding access, personalization, and flexibility. However, the author emphasizes that unmediated and unregulated use can compromise essential training processes, defending the need for guidance, supervision and balance between technological use and face-to-face interactions.

This perspective is close to the analyses of Turkle (2011), for whom digital technologies, although expanding the possibilities of connection, can produce forms of emotional distancing, replacing deep interactions with mediated bonds. Under this logic, the replacement of the caregiver's presence by digital devices can compromise the constitution of secure bonds and the capacity for symbolic elaboration. This displacement is part of the broader context of the culture of connectivity, characterized by continuous digital presence and the standardization of permanent availability (VAN DIJCK, 2013; CASTELLS, 2015).

In this logic, family mediation tends to be reconfigured according to principles of immediacy, efficiency and quick response, shifting the axis of the relationship to technological functionality.

The consequences of this process are particularly relevant in the field of moral and socio-emotional formation, since the family constitutes the privileged space for the transmission of values, norms and ethical references. When fundamental experiences such as coping with boredom, waiting, and frustration are systematically mediated by screens, the possibility of developing skills such as emotional self-regulation, empathy, and tolerance for the immediate is reduced.

Alves et al. (2025b) reinforce this concern by analyzing nomophobia from a pedagogical perspective, evidencing its impacts on students' attention, behavior, and social interaction. The authors defend the construction of educational practices that promote the conscious and responsible use of technology, highlighting the importance of joint action between family and school.

This position finds resonance in contemporary analyses that problematize the effects of digital hyperstimulation on cognitive and emotional processes, indicating that continuous exposure to intense flows of information tends to reduce attention span, hinder reflection, and compromise the construction of deeper experiences (TWENGE, 2017; CARR, 2011).

Recent evidence indicates that digital environments structured by quick rewards and constant stimuli favor patterns of immediate and superficial engagement, to the detriment of reflective processes and emotional self-regulation, contributing to increased impulsivity, mental fatigue, and fragmentation of subjective experience (TWENGE, 2017; CARR, 2011).

From the point of view of human development, the replacement of dense interactions by continuous digital stimuli compromises the construction of psychic autonomy and impoverishes the relational experience. The child learns to deal with emotions, limits and conflicts through interaction with significant adults; When this mediation is replaced by technology, there is a change in the very structure of subjective experience. Alves (2025c), when discussing Education 5.0 from the perspective of neuroscience, emphasizes that the use of smartphones and digital platforms must be subordinated to the integral development of the subject, integrating cognitive, emotional, and social dimensions, and not only to instrumental efficiency.

The relevance of this problem is reinforced in the legal field by the enactment of Law No. 15,211/2025, which establishes the Digital Statute of the Child and Adolescent. By establishing the protection of children in the digital environment as a normative principle, the legislation recognizes that early and unassisted exposure to technologies is not neutral, but directly interferes with biopsychosocial development. In this sense, the mediation of technological use is no longer just a private practice and becomes part of a field of co-responsibility between family, school, State and digital platforms.

Thus, the use of smartphones as a strategy for emotional regulation can be understood as a symptom of a structural tension of contemporaneity, marked by the acceleration of time, the centrality of technologies and the reconfiguration of family relationships.

The challenge that is imposed does not consist in the rejection of technology, but in the construction of a conscious, ethically and pedagogically oriented mediation. As Alves (2025a; 2025b; 2025c) argues, the use of smartphones and digital technologies must be linked to educational processes that promote autonomy, criticality, and integral development, preserving the irreplaceable role of human interactions in the formation of family and social values.

4 CONSEQUENCES OF DIGITAL ADDICTION

Digital addiction is configured, in contemporary times, as a highly complex phenomenon, whose repercussions go beyond the individual scope and are projected on social, educational and organizational dimensions, assuming contours of an emerging public health problem and a central challenge for education. More than a simple excess of use of technological devices, it is an unregulated relationship with digital ecosystems and platforms marked by compulsiveness, difficulty in self-control, and significant damage to mental health, quality of life, and human performance (ELHAI; DVOŘÁK; HALL, 2020; MONTAG; WALLA, 2021).

In this analytical framework, the logic of hyperconnectivity, articulated with contemporary digital culture, marked by the immediacy of responses and continuous hyperstimulation, operates as a vector for the reorganization of daily practices and modes of experience. Such a configuration tends to compromise fundamental cognitive processes, such as sustained attention and time management, while hindering the construction of denser, more reflective, and symbolically elaborated experiences, evidencing the effects of technological mediation on the quality of psychic life and social interactions (SANTAELLA, 2020; HAN, 2017).

The effects of digital addiction manifest themselves significantly at the individual level, especially through the increase in symptoms of anxiety, depression, and stress, associated with continuous exposure to digital stimuli and the recurrent search for validation and immediate rewards. This dynamic reveals that digital environments, structured by logics of engagement and social recognition, operate as reinforcement systems that intensify sensitivity to external feedback, contributing to emotional instability and dependence on quick gratification mechanisms, with direct impacts on psychological well-being (TWENGE, 2017; PRZYBYLSKI et al., 2013).

From a cognitive point of view, a set of alterations is observed associated with reduced sustained attention, impaired self-control, and difficulty engaging in activities that require

prolonged effort and continuous concentration. Such effects indicate that recurrent exposure to fragmented digital stimuli tends to reconfigure the modes of information processing, favoring more dispersed and immediate attentional patterns, with direct impacts on academic and professional performance and on the ability to perform complex and reflective tasks (CARR, 2011).

In addition, the use of digital devices as a resource for immediate psychic relief, understood as the use of *coping*, tends to reinforce cycles of dependence by consolidating patterns of emotional regulation based on the avoidance of negative affective states, such as boredom, frustration and loneliness. In this process, technology starts to be mobilized as a recurrent strategy of emotional compensation, which, although it produces momentary relief, compromises the development of psychic autonomy and self-regulation, favoring the maintenance of maladaptive coping patterns and the intensification of psychological vulnerability (RYAN; DECI, 2017; ALVES, 2025a).

However, the consequences of digital addiction are not restricted to the individual, extending significantly to social and family relationships. The constant mediation of interactions by digital devices produces a paradox characteristic of contemporary society: the expansion of the possibilities of connection accompanied by the impoverishment of the quality of bonds (TURKLE, 2011).

As a consequence, there is a decrease in empathy, a weakening of social skills, and the fragmentation of face-to-face interactions. In the family environment, mobile devices begin to compete and, in many cases, monopolize the attention of individuals, reducing the spaces for dialogue, coexistence and shared construction of values, which directly impacts the ethical and emotional formation of children and adolescents (NICOLACI-DA-COSTA, 2006; ALVES, 2025b).

This problem acquires even more critical contours when considering the specific vulnerability of children and adolescents in accessing digital platforms, social networks and electronic games. Due to their developmental condition, this audience has less capacity for self-regulation, greater susceptibility to the influence of content, and greater exposure to intensive engagement dynamics based on intermittent rewards (ALTER, 2017).

Digital environments and games are conceived from design architectures oriented to maximizing engagement and dwell time, operating through reinforcement mechanisms that encourage behavioral repetition and make it difficult to interrupt use. Such systems, often structured based on intermittent rewards and continuous stimuli, tend to intensify patterns of prolonged use, with significant impacts on sleep, school performance and mental health,

evidencing the effects of persuasive design logics on the modulation of users' behavior (MONTAG; WALLA, 2021).

In addition, unassisted access to digital environments exposes children and adolescents to relevant risks, such as inappropriate content, *cyberbullying*, data exploitation, and practices of symbolic violence. The culture of connectivity, as analyzed by Van Dijck (2013), establishes implicit norms of continuous participation, reinforcing the need to always be connected and intensifying phenomena such as *fear of missing out* (FOMO), which contributes to dependence and social anxiety (PRZYBYLSKI et al., 2013).

Under this logic, early and intensive exposure to digital technologies can be profoundly harmful, since it interferes with fundamental development processes, such as the construction of identity, the formation of values, and the development of socio-emotional skills.

At the organizational level, digital dependence also has significant implications, by introducing dynamics of continuous interruption, reducing productivity and compromising the quality of professional relationships. Permanent connectivity, associated with the overlap between personal and professional life, contributes to increased mental fatigue, anxiety, and burnout (HAN, 2017).

Paradoxically, digital technologies, associated with increased flexibility and efficiency, can, when used in an unregulated way, produce inverse effects, compromising cognitive performance and psychological well-being. Such impacts result less from their instrumental potentialities and more from the way they are incorporated into daily practices, especially when mobilized as strategies for emotional regulation. In this context, the problematic use of smartphones is associated with fragmentation of attention, cognitive overload, and difficulty in self-regulation, contributing to reduced productivity and increased stress symptoms (BUSCH; MCCARTHY, 2021).

In view of this scenario, the enactment of Law No. 15,211/2025, which establishes the Digital Statute of Children and Adolescents (ECA Digital), is a relevant regulatory framework by recognizing, at the legal level, the centrality of the digital environment in the constitution of contemporary childhood and adolescence experiences. By incorporating socio-technical dynamics as a legitimate sphere of normative incidence, the legislation not only broadens the scope of the principle of full protection, but also signals an inflection in the way in which the Law comes to understand the risks, vulnerabilities and forms of mediation implied in digital interactions.

In this sense, the Digital ECA shifts the protection of children from a strictly territorial perspective to an approach that contemplates the complexity of digital ecosystems, reaffirming

the need for regulation, supervision and co-responsibility between the State, platforms and families in guaranteeing rights in the context of hyperconnectivity (BRASIL, 2025).

By establishing the principle of the best interest of children and adolescents in the use of technologies, the legislation recognizes that digital exposure is not neutral, but involves risks that require qualified regulation. In this sense, the ECA Digital reinforces the need for active mediation, continuous supervision and co-responsibility between family, school, State and digital platforms, showing that full protection, in contemporary times, depends on the articulation between legal normativity and educational practices in the context of hyperconnectivity (BRASIL, 2025).

This perspective converges with the analyses of Alves (2025c), who advocate an educational approach aligned with Education 5.0, in which the use of technologies should be subordinated to the integral development of the subject, integrating cognitive, emotional and social dimensions.

From an analytical point of view, it is essential to understand that digital dependence does not result from the technology itself, but from the absence of qualified mediation and educational practices that guide its use.

The contemporary challenge is, therefore, to build a balanced relationship with digital environments, which recognizes their potential without neglecting their risks. This implies promoting the conscious, critical, and ethically oriented use of technologies, especially among children and adolescents, ensuring that digital innovation is at the service of human development, the preservation of social bonds, and the formation of autonomous, reflective, and emotionally healthy subjects.

5 ECA AND DIGITAL ECA: REGULATION, POWER AND MEDIATION IN THE DIGITAL ENVIRONMENT

Law No. 15,211/2025, which institutes the ECA Digital, is an offshoot of the Statute of the Child and Adolescent (Law No. 8,069/1990), by incorporating the digital environment as a space for the incidence of the principle of full protection. By recognizing that digital experiences participate in the subjective and social constitution, the legislation expands the reach of the ECA, shifting protection to a context marked by algorithmic dynamics and the centrality of platforms in the mediation of relationships. Such a movement is pointed out by recent studies as a necessary regulatory advance in the face of the insufficiency of traditional frameworks to deal with the contemporary risks of the digital environment (COMISSÃO GESTÃO DA INTERNET NO BRASIL, 2024).

In the field of social networks, ECA Digital assigns direct responsibilities to the platforms, establishing measures such as linking minors' accounts to those responsible, prohibiting behavioral profiling, and requiring control and verification mechanisms. These obligations reflect a structural change in digital governance, shifting user accountability to the technological systems themselves, which are now conceived as regulable agents. Such a perspective is consistent with the understanding that digital platforms operate as structures for capturing, analyzing, and modulating behaviors, exercising forms of power based on the extraction and processing of data and the organization of social interactions in the context of surveillance capitalism (ZUBOFF, 2019).

The sanctioning regime instituted, by providing for the application of significant fines, the suspension and even the prohibition of activities, reinforces this displacement by directly affecting the economic logic that sustains the operation of digital platforms. By affecting their monetization and operating models, the legislation introduces structural accountability mechanisms that strain the logic of maximizing engagement and data capture.

In this context, recent analyses indicate that Law No. 15,211/2025 inaugurates a new regulatory level by requiring the review of internal processes, business models, and governance strategies of technology companies, evidencing an inflection in the relationship between state regulation and the digital economy (BRASIL, 2025; ANPD, 2025).

In this context, the limitation of profiling and targeted advertising can be understood, in the light of Han (2017), as an attempt to contain the logic of the attention economy, based on the exploitation of emotional vulnerabilities and the intensification of continuous engagement.

On the other hand, although it does not provide for direct sanctions to parents or guardians, the legislation reaffirms the role of the family as a central instance of mediation. This normative choice shows that protection cannot be reduced to technical or legal mechanisms, but depends on the articulation with educational and relational practices. Recent studies highlight that the effectiveness of the Digital ECA is directly linked to the joint action of platforms, the State, and families, consolidating a model of shared responsibility (Brasil, 2025; National Data Protection Authority [ANPD], 2025).

In light of these considerations, the ECA Digital can be understood as a regulatory framework that responds to the limitations of the self-regulation of platforms, recognized as insufficient in view of the risks associated with the digital exposure of children and adolescents (BRASIL, 2025; ANPD, 2025). By imposing structural obligations and expanding institutional accountability, the law tensions the prevailing logic of hyperconnectivity, while highlighting the

limits of regulation in the face of a digital ecology guided by the capture of attention and the externalization of emotional regulation processes.

Thus, the articulation between the ECA and the ECA Digital consolidates an expanded model of full protection, in which the digital environment is recognized as a territory of rights. However, the effectiveness of this model depends not only on normative imposition, but on the ability to reconfigure the social and educational practices that sustain the use of smartphones and digital technologies, especially in the face of the growing outsourcing of emotional regulation to digital devices.

6 CONCLUSION

The analysis shows that digital addiction should be understood as an expression of structural transformations in the ways of living, learning and relating in contemporary times, marked by the growing outsourcing of emotional regulation to technological devices. In this context, the results of the study corroborate the literature by demonstrating that the use of smartphones as a strategy to cope with negative affective states significantly impacts mental health, social relationships, and educational processes.

The findings dialogue directly with Elhai, Dvořák, and Hall (2020), by confirming the association between problematic smartphone use and increased symptoms of anxiety and depression, especially when these devices are mobilized as emotional regulation resources. In a convergent way, Ryan and Deci (2017) contribute to the understanding of this phenomenon by indicating that such practices can emerge as compensatory responses to the frustration of basic psychological needs, such as belonging and autonomy.

In addition, the results reinforce the analyses of Turkle (2011) and Bauman (2001), by showing that the growing mediation of interactions by digital devices is associated with the impoverishment of social bonds and the weakening of human relationships. In this sense, it is observed that the replacement of face-to-face emotional mediation by digital strategies compromises fundamental developmental processes, especially among children and adolescents, whose vulnerability is amplified in contexts of unmediated access to technologies (BAUMAN, 2001).

From a sociotechnical perspective, the contributions of Castells (2015) and Van Dijck (2013) allow us to understand that such dynamics are not restricted to individual choices, but are inserted in a culture of connectivity that normalizes the constant presence in the digital environment. This condition is enhanced by mechanisms such as the *fear of missing out*, which

intensify the dependence on devices as a form of immediate emotional regulation (PRZYBYLSKI et al., 2013).

Additionally, the cognitive and behavioral effects observed are supported by the analyses of Carr (2011) and Twenge (2017), which point to the reduction of attention capacity, increased impulsivity, and impairment of psychological well-being resulting from continuous exposure to digital stimuli. Such evidence reinforces the understanding that digital dependence is not reduced to the time of use, but to the function that technology assumes in the subject's life.

In view of these findings, digital addiction should be understood as an expression of socio-technical dynamics that reconfigure the processes of emotional regulation, as defended by Alves (2025a; 2025b; 2025c), based on conscious, critical, and ethically oriented mediation of the use of technologies. More than restricting access, it is about qualifying the relationship with the digital environment, reaffirming the central role of human interactions in emotional regulation and integral development. This perspective is also supported by the normative framework established by Law No. 15,211/2025, which recognizes the need for protection and mediation in the use of technologies by children and adolescents.

In this context, it is necessary to adopt educational approaches that prioritize qualified mediation and the development of self-regulation skills and critical use of technologies. Thus, the promotion of a balanced relationship with digital environments depends less on restrictive strategies and more on the construction of formative practices that articulate cognitive, emotional and social dimensions in the conscious and functional use of digital technologies. The outsourcing of these functions to digital devices implies relevant shifts in the management of affective states, with impacts on psychological autonomy and socio-emotional skills.

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LANDING PAGES IN LOCAL RETAIL: METRICS, EXPERIMENTATION, AND INFRASTRUCTURE DEPENDENCE IN LOW-DEMOGRAPHIC MARKETS

LANDING PAGES NO VAREJO LOCAL: MÉTRICAS, EXPERIMENTAÇÃO E DEPENDÊNCIA INFRAESTRUTURAL EM MERCADOS DE BAIXA DEMOGRAFIA

PÁGINAS DE DESTINO EN EL COMERCIO MINORISTA LOCAL: MÉTRICAS, EXPERIMENTACIÓN Y DEPENDENCIA DE LA INFRAESTRUCTURA EN MERCADOS CON BAJA DEMOGRAFÍA



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ABSTRACT

In low-demographic contexts, low traffic volume makes the interpretation of standardized landing page metrics more unstable. This article analyzes a real local retail campaign based on the reanalysis of data from Google Analytics 4, Microsoft Clarity, heatmaps, and interface logs. Methodologically, it is an exploratory case study, with elements of A/B experimentation in a natural environment, guided by Media Ecology, Software Studies, the discussion on platformization, and usability literature. The reanalysis suggests that CTA performance depends on the interface environment, the device, and the funnel stage; that dwell time and scroll depth are useful metrics, but insufficient when interpreted in isolation; and that performance interpretation becomes more aligned with the page's objective when articulated with signals closer to the payment flow. As a contribution, the article proposes a situated interpretation of performance metrics and derives a lightweight test governance protocol for landing pages in information-scarce contexts.

Keywords: Landing Pages. Low Demographics. Platformization. Usability. Local Retail.

RESUMO

Em contextos de baixa demografia, o baixo volume de tráfego torna mais instável a leitura de métricas padronizadas em *landing pages*. Este artigo analisa uma campanha real de varejo local com base na reanálise de dados do Google Analytics 4, Microsoft Clarity, mapas de calor e registros de interface. Metodologicamente, trata-se de um estudo de caso exploratório, com elementos de experimentação A/B em ambiente natural, orientado pela Ecologia da Mídia, pelos Software Studies, pela discussão sobre plataformação e pela literatura de usabilidade. A reanálise sugere que o desempenho do CTA depende do ambiente de interface, do dispositivo e da etapa do funil; que tempo de permanência e profundidade de rolagem são métricas úteis, porém insuficientes quando interpretadas

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isoladamente; e que a leitura do desempenho se torna mais aderente ao objetivo da página quando articulada a sinais mais próximos do fluxo de pagamento. Como contribuição, o artigo propõe uma leitura situada das métricas de desempenho e deriva um protocolo leve de governança de testes para landing pages em contextos de escassez informacional.

Palavras-chave: Landing Pages. Baixa Demografia. Plataformização. Usabilidade. Varejo Local.

RESUMEN

En contextos con baja demografía, el escaso volumen de tráfico dificulta la interpretación de las métricas estandarizadas de las páginas de destino. Este artículo analiza una campaña real de venta minorista local a partir del reanálisis de datos de Google Analytics 4, Microsoft Clarity, mapas de calor y registros de interfaz. Metodológicamente, se trata de un estudio de caso exploratorio, con elementos de experimentación A/B en un entorno natural, guiado por la ecología de los medios, los estudios de software, el debate sobre la plataformización y la literatura sobre usabilidad. El reanálisis sugiere que el rendimiento de la llamada a la acción (CTA) depende del entorno de la interfaz, el dispositivo y la etapa del embudo de conversión; que el tiempo de permanencia y la profundidad de desplazamiento son métricas útiles, pero insuficientes si se interpretan de forma aislada; y que la interpretación del rendimiento se alinea mejor con el objetivo de la página cuando se articula con señales más cercanas al flujo de pago. Como contribución, el artículo propone una interpretación contextualizada de las métricas de rendimiento y deriva un protocolo de gobernanza de pruebas ligero para páginas de destino en contextos con escasez de información.

Palabras clave: Páginas de Destino. Baja Demografía. Plataformización. Usabilidad. Venta Minorista Local.

1 INTRODUCTION

This article analyzes a local retail landing page in a context of low demographics, based on a real campaign carried out in Barra do Corda, Maranhão, between June 3 and August 31, 2024. In markets of this type, the low volume of traffic makes each visit more relevant and makes it more sensitive to read the performance of the interface. In this scenario, the landing page is no longer just a promotional piece and starts to function as a privileged object to observe how metrics, interface elements, and local conditions are articulated in the production of results.

The analysis is based on operational data from Google Analytics 4 (GA4), Microsoft Clarity heat maps and behavioral logs, as well as simple interface variations tested throughout the campaign. The central problem of the article lies in the fact that, in low-traffic environments, small oscillations in layout, access source, device, and local seasonality can produce disproportionate effects on metrics such as clicks, dwell time, and scroll depth. In these contexts, the automatic reading of standardized indicators tends to be insufficient, as the scarcity of signals makes the interpretation of performance more unstable and requires greater attention to the context in which the interaction occurs.

This question gains relevance because a significant part of the literature on *landing pages*, optimization, and digital performance was produced based on scenarios of abundant traffic and relatively stable patterns of user behavior. Such a framework does not always correspond to the reality of local retail in smaller municipalities, in which the availability of data is reduced and analytical decisions have to deal with more noise, greater sensitivity to conjunctural variations, and stronger dependence on the digital infrastructures that organize measurement. The originality of the study lies, therefore, in shifting the debate to an environment in which measuring does not only mean recording interactions, but interpreting scarce signals in a situated way.

Given this scenario, the article aims to analyze how the reading of the performance of a landing page is organized in a context of low demographics. More specifically, it seeks, first, to examine the conditionality of the *Call To Action* (CTA), considering its relationship with the funnel, the device and the interface environment; second, to discuss the limits of attention metrics, such as dwell time and scroll depth, when mobilized in low-sampling scenarios; and, third, to propose a lightweight protocol of situated reading and test governance, Able to guide analytical decisions in contexts of information scarcity.

The contribution of the article is twofold. On the empirical level, it examines a real local retail campaign in a low-demographic market, contributing to broaden the repertoire of studies on digital performance in peripheral and underexplored contexts. On the methodological level,

it proposes a situated reading of performance metrics in *local retail landing pages*, articulating the empirical case with the discussion on platformization, usability and informational scarcity, and deriving from this path a lightweight protocol of test governance.

2 THE ECOLOGY OF THE MEDIA AND THE INTERFACE ENVIRONMENT

Media ecology shifts the analytical focus from isolated content to the environment that makes communication possible, intelligible, and socially operable. From this perspective, the media do not function only as transmission channels, but as structures that organize perception, modulate attention and condition the action of the subjects. Applied to the study of digital interfaces, this approach allows us to understand the landing page not only as a promotional piece or information support, but as a technical and symbolic environment that frames the user's behavior and guides their navigation (McLuhan, 1995).

This framing is especially relevant for the analysis of *landing pages*, as their performance does not depend only on the content offered, but on the articulation between the position of the elements, visual hierarchy, density of stimuli, loading temporality, and clarity of the action path. Elements such as the CTA, the order of the blocks, the presence of fixed components above the fold, and the proximity between information and payment do not operate in isolation. Their effect is relational, that is, it emerges from the interface environment in which they are inserted.

In contexts of low demographics, this perspective gains additional analytical strength. When traffic volume is reduced, small environmental changes can produce proportionally more visible oscillations in observed behavior. In these scenarios, the environment ceases to be a backdrop and becomes a central variable of interpretation. Media ecology, therefore, offers a useful key to understanding why, in small markets, metrics and behaviors need to be read in light of the concrete conditions of interface and circulation.

In dialogue with this axis, *software studies* allow us to observe how such conditions are technically operationalized. If media ecology emphasizes the environment, software studies help to understand how this environment is structured by systems, dashboards, event taxonomies, and ways of visualizing data. Dashboards, APIs, and analytical tools don't just record experience: they define which actions will be visible, which relationships can be compared, and which problems will be recognized as amenable to optimization (Manovich, 2013). In other words, the user experience is simultaneously lived and modeled in a technical grammar that conditions its interpretation.

2.1 PLATFORMIZATION, METRICS, AND LOCAL VALUE

The discussion about platformization allows us to broaden this reading by situating the landing page within a broader ecosystem of infrastructures, metrics, and forms of governance. In Van Dijck, Poell and de Waal (2018), platformization refers to the expansion of digital platforms as structures that organize social, economic and cultural practices through logics of datafication, monetization and regulation. More than hosting interactions, these infrastructures define visibility standards, measurement criteria, and legitimate forms of circulation and conversion.

In the case of *landing pages*, this means that performance is now read through a vocabulary strongly stabilized by platforms and analytics tools: time engaged, click-through rate, scroll depth, conversions, and other similar metrics. These indicators are useful because they make campaigns comparable and offer relatively standard operating parameters. However, they also function as normative artifacts: by privileging certain events and making others invisible, they help define what counts as success. In this key, measuring is not just describing; it is also to frame value.

This issue becomes even more sensitive in contexts of low demographics. When the volume of data is reduced, the effects of seasonality, variation in traffic origin, differences between devices, and sampling instabilities increase. Under such conditions, standardized metrics preserve comparative utility, but tend to lose strength when mobilized in isolation as evidence of performance. The reading of the panel now requires greater caution, since small oscillations can represent both relevant indications and simple contextual noise.

It is at this point that the notion of local value becomes decisive. Instead of taking success only as what the platform measures in a more visible way, it becomes necessary to put the concrete purpose of the interface in its context of use back at the center. On a local retail landing page with a payment-oriented flow via QR/Pix, for example, the interpretation of performance cannot depend only on generic attention proxies. It also needs to consider signs closer to the effective progression of the desired action. The problem, therefore, is not to abandon standardized metrics, but to articulate their comparability with indicators that are more adherent to the local objective of the interaction.

This perspective dialogues with Nieborg and Poell (2018), by showing that platforms not only host content, but co-produce their own evaluation objects by stabilizing taxonomies, events, and optimization formats. In peripheral markets and smaller-scale operations, this implies additional asymmetries: teams tend to rely on externally defined analytical repertoires, often without control over criteria for visibility, modeling, or data suppression. Grohmann's

(2019) critique helps to situate this problem as a matter of power and analytical capacity: the smaller the local structure, the greater the dependence on ready-made metric grammars. Therefore, a situated reading of metrics is not opposed to platforms, but seeks to prevent them from defining on their own what should be understood as a relevant result.

2.2 USABILITY AND EXPERIMENTATION IN THE CONTEXT OF SCARCITY

The usability literature contributes to this debate by offering a procedural framework for the interpretation and improvement of interfaces. Instead of treating usability only as a set of good visual practices, it is interesting here to understand it as a process discipline: a way to reduce friction, qualify paths, and make the relationship between interface and user behavior more readable. In Nielsen (1993; 1994), the evaluation of usability is built through inspections, tests and systematic observation, based on the principle that basic interaction problems need to be treated before decisive effects are attributed to small variations in layout, color or *microcopy*.

This principle is particularly important in low-traffic environments. In contexts of informational scarcity, each interface change operates on a reduced set of signals, which makes it more difficult to distinguish what results from a specific change and what results from contextual noise. For this reason, experimentation cannot be conducted as a simple succession of visual tests, but must start from minimum conditions of legibility, hierarchy, clarity of flow and operational stability. In other words, before testing for fine differences, you need to make sure that the page isn't producing elementary friction that distorts the reading of the behavior.

This approach is close to the formulations of Marketing 4.0 and 5.0, especially when these works emphasize the centrality of experience, continuous learning, and data-driven adaptation (Kotler, Kartajaya, and Setiawan, 2017; 2021). In local retail operations, however, this logic needs to be calibrated to the size of the market and the actual availability of analytical signals. Rather than relying on extensive cycles and large volumes of observations, experimentation tends to work best when guided by small hypotheses, minimally stable observation windows, and explicit reading and decision criteria.

From this perspective, usability and experimentation converge on the same point: the need to build responsible interpretations in environments of scarcity. This entails not only testing interface elements, but doing so with analytical parsimony, recognizing that attention metrics such as dwell time and scroll depth can be useful, though insufficient when taken in isolation. In low-demographic markets, reading performance requires combining observation of the

interface environment, understanding the context of use, and selecting indicators closer to the specific purpose of the page.

Thus, the dialogue between media ecology, platformization, and usability provides the conceptual basis of this article. Media ecology allows us to understand the landing page as an environment of perception and action; platformization shows how metrics and infrastructures condition what can be seen as value; and usability provides a procedural horizon for thinking experimentation and decision making in low-traffic contexts. Together, these axes support the proposal of a situated reading of performance, suitable for local operations in which measuring well depends less on accumulating large volumes of data than on rigorously interpreting scarce and contextually marked signals.

3 METHODOLOGY

3.1 RESEARCH DESIGN AND EMPIRICAL CONTEXT

This article adopts a methodological design of an exploratory case study, with reanalysis of a real landing page campaign conducted in a context of low demographics. The mobilized data were originally collected and analyzed within the scope of a master's dissertation presented to the Graduate Program in Communication of the Federal University of Maranhão (PPGCom/UFMA), being reinterpreted here in the light of a new theoretical and analytical framework, centered on the articulation between media ecology, platformization, usability and informational scarcity.

The empirical case corresponds to a local retail campaign carried out in Barra do Corda (MA), between June 3 and August 31, 2024, with a landing page oriented to conversion and payment via QR/Pix. Although the corpus dialogues with elements of A/B experimentation in a natural environment, especially with regard to simple interface variations throughout the campaign, the article does not claim robust statistical demonstration of causality. Its objective is, rather, to produce a situated interpretation of the page's performance in conditions of low traffic volume, taking the available metrics and records as empirical evidence to be read in articulation with the interface context and with the inferential limits of the case.

The choice of this design stems from the nature of the problem investigated. In low-demographic markets, the scarcity of signals, the greater sensitivity to local seasonalities, and the relative instability of some metrics make an analytical approach guided by triangulation and contextualization more productive than by universalizing pretensions. Thus, the case study allows us to observe, in depth, how interface elements, standardized metrics and payment flows are articulated in a concrete empirical environment of local retail.

3.2 DATA SOURCES AND ANALYTICAL CORPUS

The analytical corpus was composed of different types of operational and documentary records. The main database gathered data from Google Analytics 4 (GA4) and Microsoft Clarity, including navigation metrics, dwell time, scroll depth, useful clicks, heatmaps, and recorded sessions. To these materials were added variants of the landing page, screenshots and interface configuration notes produced throughout the campaign, used to document changes in layout, block order, microcopy, CTA chromia and payment flow position.

The campaign's consolidated data indicated 1,698 users, 23 clicks on CTA, 56 interactions with Pix/QR and 79 clicks classified as conversion, in addition to an average scroll depth of 26.79% and an average dwell time of 29 seconds. These numbers were treated, in this article, not as sufficient evidence to prove causal relationships between interface variations and conversion outcomes, but as empirical indicators of the user journey and the way performance was captured by the available analytical tools.

For interpretation purposes, it is important to distinguish three levels of registration present in the corpus. CTA clicks correspond to direct interaction with the main action command of the page; interactions with Pix/QR are about the user's progression towards the payment flow; and clicks classified as conversion bring together events treated operationally, in the original corpus, as signs of relevant progress in the journey. As this is a reanalysis of data already collected, the equivalence between these levels is not automatically assumed, but carefully examined, recognizing that each record expresses a distinct layer of the observed behavior. This distinction is methodologically important because it avoids taking every interaction as a synonym for completed conversion.

In addition, the article starts from the recognition that the corpus is conditioned by the very logic of visibility of the analytical platforms used. This means that the available data does not exhaust the user experience, but translates it according to taxonomies, filters, and registration criteria technically defined by GA4 and Clarity. In this way, the corpus is understood simultaneously as an empirical source and as a product of a specific metric grammar, whose reading needs to be contextualized.

Figure 1

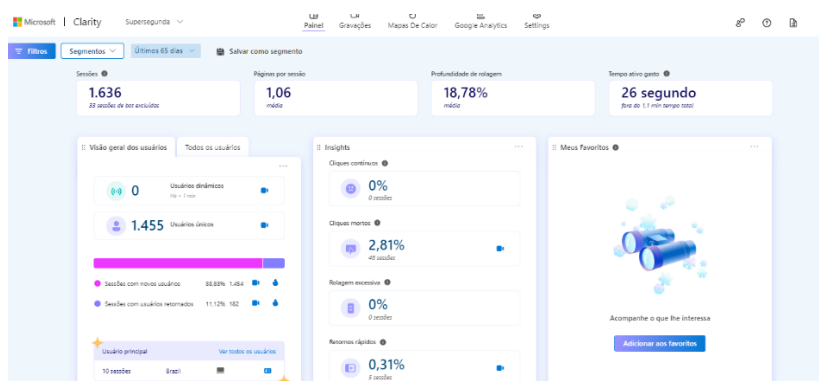
Interface of the "Super Segunda Unillar" landing page, used in the analyzed campaign, highlighting the organization of the visual elements, content hierarchy and positioning of the payment flow



Source: Unillar.com.br.

Figure 2

Campaign performance dashboard in Microsoft Clarity, presenting user interaction and behavior metrics after the data collection period



Source: Microsoft Clarity.

3.3 OPERATIONAL DEFINITIONS

The analysis was structured based on some operational definitions aimed at making the criteria for reading the observed behavior more explicit. The main one is the notion of "qualified visit", mobilized in this article as an analytical operator to identify situations in which there was minimal evidence of attention and/or progression in the flow of the interface. Instead of taking any visit as a homogeneous unit, the category seeks to distinguish accesses with more consistent indications of engagement or purpose.

For this classification, the occurrence of at least one of the following criteria was considered as a qualified visit: (a) combination of minimum attention, expressed as a dwell time equal to or greater than 12 seconds and scroll depth equal to or greater than 60%; (b) presence of informational microinteraction, understood as an action indicative of active search for content or progression in the path; or (c) a sign of progress in the payment flow, ideally associated with the display of the QR code and staying in its area long enough to indicate action-oriented attention.

However, in the empirical case reanalyzed here, not all of these events were fully instrumented at the desirable level for a closed demonstration. In particular, the display of the QR code and the time spent in its area appear in the article less as variables fully measured in the corpus and more as analytical operators and methodological propositions derived from the observed limitation itself. For this reason, the definition of qualified visit should be understood in two ways: as an interpretative resource applied to the available material and, simultaneously, as a more robust methodological formulation for future applications in similar contexts.

A minimum observation window of 14 days was also assumed as parameters for reading the corpus, designed to cushion weekly variations and conjunctural oscillations, and the

adoption of explicit criteria for analytical decision, such as distinction between relevant advance, absence of interpretable gain and occurrence of error or collection noise. These parameters do not operate, here, as a fully validated experimental protocol, but as principles of methodological organization coherent with the proposal of a situated reading of performance.

3.4 ANALYSIS PROCEDURES AND INFERENTIAL LIMITS

The reading of the material was organized into three analytical axes, corresponding to sectors of the user journey on the landing page: (1) interface and CTA, including color, contrast, microcopy, visual hierarchy, and competition of stimuli above the fold; (2) engagement and scrolling, with attention to the interpretive limits of dwell time and scroll depth; and (3) payment flow, taking as a reference the available indications of progression towards QR/Pix and the need for metrics that are more adherent to the local purpose of the interface. This sectorization was not thought of as rigid compartmentalization, but as an analysis strategy to relate different layers of recorded behavior.

The analytical procedure combined quantitative reading and contextual interpretation of the records. Aggregated metrics of attention and interaction were examined in conjunction with heat maps, documentation of page variants, and observation of friction or visibility points in the user journey. Instead of taking time, scrolling, or clicks as self-evident indicators, the analysis sought to triangulate them with the organization of the interface, the position of the relevant elements, and the context of circulation of the campaign. In this sense, the reanalysis sought to shift the focus from a merely descriptive reading of the numbers to a situated interpretation of the available signs.

The analysis also considered stratification by device and stage of the funnel, especially in the distinction between colder accesses and return situations, whenever the corpus allowed this type of reading. However, such stratifications were treated with caution, since the low volume of traffic and the platforms' own modeling and privacy rules can reduce the stability of finer segmentations. Thus, the inferences produced throughout the article are deliberately moderated: it is less a matter of asserting universal effects and more of understanding how the empirical case illuminates recurring problems of measurement in low-demographic markets.

Among the main inferential limits of the study are the reduced volume of data, the sensitivity of metrics to local seasonality, the dependence on analytical tools with their own criteria for recording and visualization, and the absence of more precise instrumentation for some events considered central to the progression in the payment flow. For this reason, the results presented in the following sections should be read as situated inferences, supported by

triangulation between different registers, and not as robust generalizations about causality on *landing pages*. Such delimitation does not diminish the relevance of the case; on the contrary, it reinforces its usefulness as an empirical basis for thinking about test analysis and governance practices in contexts of information scarcity.

4 RESULTS AND DISCUSSION

4.1 CTA, VISUAL HIERARCHY, AND CONTEXT OF USE

The analyzed campaign registered 1,698 users and 23 clicks on the CTA, which corresponds to 1.35% of the observed accesses. Taken in isolation, this percentage does not allow us to conclude, in a direct way, whether the button is effective or ineffective as a conversion device. However, when read in conjunction with the interface configuration and navigation logs, it suggests that the CTA did not operate as a universal trigger for action, but as an element dependent on the environment in which it was inserted.

Observing fixed elements above the fold, such as header and floating icons, reinforces this reading. In low-demographic contexts, where each access has greater analytical weight and competition for attention becomes more sensitive, the effect of isolated attributes—such as color, contrast, or button shape—tends to be diluted when the navigation path has high visual competition. In these cases, the position of the CTA in the flow of the page, its relationship with the informational blocks, and its proximity to the moment of payment seem more relevant than chromatic adjustments considered separately.

The reanalysis also suggests that microcopy participates decisively in this conditionality. More specific and task-oriented labels, such as those that clearly indicate the transition to payment via QR, tend to reduce ambiguity and produce greater adherence to the purpose of the page than generic statements. This does not mean attributing to microcopy a linear or universal effect, but recognizing that, in low-traffic environments, the clarity of the path can have more weight than small isolated visual variations, especially when the user already has some previous familiarity with the offering.

From a theoretical point of view, this result reinforces the ecological reading of the interface. The CTA should not be understood as an autonomous unit of conversion, but as part of a technical and perceptive environment that organizes the user's action. Its effectiveness, therefore, depends on the articulation between visual hierarchy, stimulus density, funnel context, and concrete navigation conditions. Rather than looking for a "pure effect" of the button, the case suggests that call-to-action performance needs to be interpreted as a relational

phenomenon, situated and sensitive to the scarcity of signals conditions typical of low-demographic markets.

Figure 3

Heat map of clicks and scrolling depth of the landing page, evidencing interaction patterns and distribution of users' attention throughout the interface



Source: Microsoft Clarity

4.2 TIME, SCROLLING, AND INTERPRETIVE NOISE

In the campaign as a whole, the average scrolling depth was 26.79%, while the average time spent on the page was 29 seconds, totaling approximately 13 hours and 42 minutes of aggregate dwell. These indicators are relevant to reading browsing behavior, but cannot be taken by themselves as automatic equivalents of interest, intent, or progress in the conversion path.

First, dwell time can include situations in which the page remains open without effective interaction, either due to interrupted browsing or by staying in the background. Second, the low average scroll depth should not be automatically interpreted as page bounce, especially when information central to the action — such as price, payment terms, or the actual access to the purchase flow — is positioned in the first sections of the interface. In this case, less scrolling can mean both disinterest and quick access to the point considered most relevant by the user.

The case, therefore, suggests that attention metrics need to be read in a situated key. In low-demographic contexts, small changes to traffic source, device, local calendar, and page

organization can produce disproportionate swings in timing and scrolling. For this reason, these indicators preserve descriptive and comparative usefulness, but become insufficient when mobilized in isolation as proof of performance. The attention observed in the analytical tools does not necessarily coincide with intention, just as the scanning of the interface does not in itself equate to the rejection of the content.

It is at this point that triangulation is methodologically necessary. Instead of treating time and scrolling as self-evident proxies of success, the analysis proposes to interpret them in conjunction with informational microinteractions, documentation of page variants, and clues closer to the payment flow. Such a movement does not invalidate the standardized metrics of the platforms, but it reduces the risk of their fetishization, that is, the risk of taking as a result what the panel shows in a more visible way, and not necessarily what comes closest to the concrete objective of the interface.

4.3 PAYMENT FLOW AND INTENT SIGNALS

For interpretation purposes, the corpus was read in three levels of registration. The first corresponds to clicks on CTA, understood as direct interaction with the main action command of the page. The second concerns interactions with Pix/QR, taken as signs of progression in the payment flow. The third group includes the 79 clicks classified as conversion, that is, events operationally treated in the original corpus as relevant advances in the user's journey, although not equivalent, by themselves, to the completion of the payment.

This distinction is methodologically necessary because it prevents taking every interaction as a synonym for effective conversion and makes the reading of the different layers of the observed behavior more accurate.

This data is especially relevant because it occurs in a scenario of low average scroll depth. This suggests that, even without going through long stretches of the page, a portion of users were able to access the payment flow, which replaces the visibility and organization of this journey as decisive factors for analysis.

In other words, the case indicates that the efficiency of the landing page does not depend only on retaining attention for longer, but on making the shift between information, decision, and payment readable and accessible. When that short flow — CTA, payment block, and QR — is well-placed, conversion can lean more on the clarity of the journey than the length of the navigation.

At the same time, the analysis itself highlights a decisive limitation of the corpus: the absence of specific instrumentation for events such as effective display of the QR code and

time spent in its area. This restriction prevents conclusive affirmation of the empirical superiority of these signals in relation to the generic metrics of attention in the case studied. What the article can sustain more rigorously is something slightly different and, methodologically, stronger: the reanalysis shows that traditional indicators alone do not capture the progression in the payment flow and, therefore, points to the need to instrument signals that are more adherent to the local purpose of the interface in future applications.

In this key, the payment flow emerges less as the final step of a linear funnel and more as a critical operator for reading performance. By shifting analytical attention to events closer to the transaction, the study proposes a shift in focus: in contexts of informational scarcity, it is less important to multiply general engagement proxies and more to identify which signals are, in fact, closer to the action that the interface intends to enable. Thus, the contribution of the case is not to demonstrate in a closed way the strength of indicators such as QR rendering and dwell time, but to highlight their analytical relevance and their methodological necessity.

4.4 WHAT THE CASE SHOWS ABOUT LOW DEMOGRAPHICS AND SITUATED METRICS READING

Taken together, the case study shows that the measurement problem in low-demographic markets is not limited to the existence of less data, but to the presence of more context-sensitive data. In campaigns with low traffic volume, variations in layout, access source, device, and local seasonality can significantly alter aggregate metrics, making it more difficult to distinguish what corresponds to a consistent interface effect and what results from conjunctural noise. In these scenarios, scarcity is not just quantitative limitation; it constitutes a specific analytical condition.

This condition reinforces the need to articulate two complementary reading lenses. The first is the platform's lens, which offers standardized metrics, comparability, and monitoring basis. The second is the lens of local value, which puts the concrete purpose of the page back at the center and requires attention to signs closer to the desired action. In the case examined here, this means recognizing the usefulness of clicks, timing, and scrolling, without allowing such indicators to define on their own what should be understood as success.

From the point of view of theoretical discussion, the empirical case sustains three movements. First, it reinforces the ecological reading according to which elements such as CTA, blocks of information and payment can only be understood in their relationship with the interface environment. Second, it confirms the criticism of the naturalization of the metrics prescribed by the platforms, showing that they frame the perception of performance, but do not exhaust their

intelligibility. Third, it suggests that usability, understood as a process, needs to function as a precondition for experimentation, especially in contexts in which low traffic makes it more difficult to interpret fine changes in behavior.

In summary, the reanalysis indicates that the reading of the performance of *landing pages* in low-demographic markets should be guided less by supposedly stable metric truths and more by situated interpretations, capable of combining standardized indicators, observation of the interface environment, and signals more adherent to the local purpose of the interaction. It is in this shift that the case gains relevance: not as a basis for strong generalizations, but as applied evidence that, in peripheral and low-scale contexts, measuring well depends less on accumulating large volumes of data than on accurately interpreting scarce and contextually marked signals.

5 PROPOSED TEST GOVERNANCE PROTOCOL

The reanalysis of the campaign allows us to derive, from the empirical case, a methodological proposition aimed at conducting tests on *local retail landing pages* under conditions of low demographics. Instead of taking the case as a basis for the formulation of retroactive hypotheses, this section uses it as a foundation to propose a lightweight test governance protocol, guided by traceability, analytical parsimony, and adherence to the local value of the interface. The objective of the protocol is to provide minimum parameters for conducting and interpreting experiments in contexts in which the volume of traffic is low, sensitivity to contextual factors is high, and standardized metrics, although useful, are not enough to support decisions in isolation.

The proposal is based on the recognition that, in markets with low demography, experimentation cannot depend on an ideal of informational abundance that is rarely realized in practice. Under these conditions, decision-making tends to be more consistent when supported by simple, explicit, and stable procedures, capable of reducing interpretative noise and preventing episodic oscillations from being confused with robust evidence. The suggested protocol, therefore, does not seek to replace the metric grammar of the platforms, but to discipline its use from a situated framework, in which the canonical metrics are read in articulation with signs closer to the concrete purpose of the page.

In this sense, three analytical axes are proposed to guide the governance of the tests:

- **The conditionality of the CTA**, that is, the recognition that the performance of the call to action should not be evaluated as an autonomous and universal effect, but in relation

to the context of use, the stage of the funnel, the access device and the organization of the interface environment.

- **The insufficiency of attention metrics taken in isolation**, considering that dwell time and scroll depth, although relevant, can become noisy in low-sampling scenarios and, therefore, need to be triangulated with microinteractions and signals that are more adherent to the payment flow.
- **The need for a lightweight decision protocol**, based on prior rules and explicit reading criteria, to reduce interpretation biases and increase the consistency of analytical choices.

Based on these axes, the protocol recommends, first, the adoption of a **light pre-registration** for each test, containing the operational hypothesis, the variation applied, the main monitoring metric, the minimum observation window, and the decision rule. This pre-registration does not need to reproduce the formalization of large-scale statistical experiments, but it should be sufficient to establish, before execution, what is expected to be observed and under what conditions a variation will be interpreted as promising, inconclusive or problematic. The function of this procedure is to reduce the possibility of interpretative adjustments made a posteriori, preserving greater traceability in the decision-making process.

Secondly, the protocol proposes to define a **minimum observation window**, preferably of two weeks, in order to buffer oscillations associated with specific days, irregular traffic flows and local seasonalities. In contexts of low demographics, periods that are too short tend to amplify noise and make any variation more vulnerable to hasty readings. Observation by minimal windows does not eliminate data instability, but it improves comparability between different moments of the campaign and favors decisions less dependent on occasional fluctuations.

Thirdly, it is recommended to **freeze the other relevant variables during the test**, avoiding simultaneous changes in layout, traffic origin, offer or positioning of central elements of the page. As the volume of accesses is reduced, competing changes make interpretive attribution even more difficult and make the experiment less readable. From this perspective, governing the test also means constraining parallel interventions, so that the observed variation can be read in relation to a minimally stable environment.

The fourth component of the protocol is the adoption of a **minimal event dictionary**, which allows distinguishing different layers of user behavior in the page path. Instead of treating every interaction as equivalent, the proposal is to separate at least four levels: interaction with

the CTA, visibility of the payment block, progression towards QR/Pix, and signals closer to the effectiveness of the intended action. In the specific case analyzed in this article, the absence of finer instrumentation for displaying the QR code and staying in its area was identified as an important limitation; Therefore, the protocol now explicitly recommends that these events be incorporated into future applications, whenever technically feasible.

The fifth element concerns the **decision criteria**. Instead of pursuing an ideal of statistical significance that is difficult to sustain in low-scale operations, the protocol proposes to work with three decision-making categories: interpretable gain, absence of relevant gain, and execution error or noise. The first category corresponds to situations in which the tested variation shows consistent signs of improvement in relation to the local objective of the interface; the second covers cases in which the observed difference does not justify a practical change; and the third includes collection failures, instability of the experiment or external interference that makes reading unfeasible. This typology does not solve the problem of scarcity by itself, but organizes the decision in a more transparent way that is compatible with the real conditions of the field.

Finally, the protocol recommends maintaining a **synthetic record of the tests performed**, bringing together the execution period, observed variant, main metrics, decision made, and any incidents. This turns the experiment into cumulative analytical memory, allowing local operations to learn from their own variations instead of relying solely on generic prescriptions offered by external dashboards and models. In peripheral environments and lean teams, this cumulativeness is particularly important, because knowledge about public behavior tends to be built less by the abundance of data and more by the rigorous systematization of scarce signals.

Thus, the proposed protocol should not be understood as a closed, universal model or fully validated by this research, but as a methodological proposition derived from the reanalysis of the case, aimed at guiding decisions in contexts of low demographics.

Its central function is to put the local purpose of the interface back at the center of interpretation, articulating standardized metrics, observation of the use environment, and explicit analytical governance criteria.

Table 1 summarizes, in a propositional key, the operational components of this protocol, understood as an initial formulation to be refined in future applications:

Table 1

Lightweight test governance protocol for landing pages in low-demographic contexts

Dimension	Description
Objective	Standardize the conduct of tests on <i>local retail landing pages</i> under traffic scarcity, ensuring reproducibility, transparency and alignment of metrics with local value (payment via QR code).
Hypothesis	Objective formulation, in a single sentence, indicating the relationship between the variation applied and the expected result (e.g., increase of qr_render and qr_dwell_s ≥ 6 s).
Benchmark Metrics	QR code display rate (qr_render, %) and time spent in the QR area (qr_dwell_s, in seconds).
Observation window	Minimum period of 14 days, including weekly variations in behavior.
Decision criteria	Vitória: $\geq +2$ p.p. in qr_render and $\geq +3$ s in qr_dwell_s; Futility: absence of relevant gain; Error: Collection or execution failures.
Monitored events	Interaction with CTA; payment block visibility (≥ 1 s); display of the QR code; length of stay in the QR area; optional: copy of the Pix key.
Qualified visit	Occurrence of at least one of the following criteria: (i) time ≥ 12 s and rollover $\geq 60\%$; (ii) informational microinteraction; (iii) QR displayed permanently ≥ 6 s.
Usability (control)	Readability, CTA contrast, visible focus, and mobile-friendliness.
Performance (control)	Page loading stability (e.g., proper LCP and TBT).
Ethics (control)	Availability of a user-accessible privacy policy.
Experimental control	Absence of simultaneous changes to the interface or traffic sources during test execution.
Follow-up	Periodic checks of the stability of the experiment, the correct triggering of events and the integrity of the interface.
Reporting of the results	Period record, variant distribution, key metrics (qr_render and qr_dwell_s), decision (win/futility/error), verification of controls and incidents.
Attachments	Inclusion of empirical evidence (screenshots, data logs, change logs).
Context and traceability	Prior registration of hypotheses, metrics, interface freezing, seasonality factors, and analytical segmentation (device and funnel stage).

Source: The authors.

6 CONCLUSION

This article analyzed the performance of a local retail landing page in the context of low demographics, from a campaign carried out in Barra do Corda (MA), based on records from Google *Analytics* 4, Microsoft Clarity, heat maps and documentation of interface variations. By shifting the discussion about *landing pages* to an environment with low traffic volume, the study sought to understand not only the user's behavior in front of the page, but above all the limits and possibilities of measurement in contexts marked by scarcity of signals, infrastructural dependence, and strong sensitivity to contextual variations.

The reanalysis suggests, firstly, that the CTA cannot be understood as an autonomous element of conversion. Its performance appears conditioned by the organization of the interface environment, the stage of the funnel, the access device and the articulation with elements such as visual hierarchy, clarity of the path and microcopy. Second, the study indicates that attention

metrics such as dwell time and scroll depth remain useful as descriptive indicators, but become noisy when mobilized in isolation as evidence of intent or performance. Thirdly, the case reinforces the need to approximate the analytical reading of signals that are more adherent to the specific purpose of the page, especially those related to the payment flow, even though the reanalyzed corpus does not allow conclusively demonstrating the empirical superiority of these indicators in the specific case.

In this sense, the main empirical contribution of the article is to show that, in markets with low demography, the problem of measurement does not arise only from the existence of less data, but from the presence of data that are more sensitive to seasonality, traffic origin, device, and interface organization. Scarcity, therefore, is not just a quantitative limit; it constitutes an analytical condition of its own. This requires that the reading of performance be done with greater interpretive caution and with less dependence on standardized metrics taken as self-evident truths.

From a methodological point of view, the article contributes by proposing a situated reading of performance metrics in *local retail landing pages*, articulating media ecology, platformization, and usability to interpret scarce signals in a way that is more adherent to the local value of the interaction. From the case analyzed, a lightweight test governance protocol is derived, guided by simple pre-registration, minimum observation window, explicit decision criteria, and attention to indicators closer to the purpose of the interface. This proposal should not be understood as a universal model or as a fully validated protocol in a statistical sense, but as an initial methodological arrangement, compatible with local operations and with conditions of information scarcity.

The limits of the study need, however, to be kept in the foreground. The low volume of traffic, the sensitivity of metrics to contextual factors, the constraints imposed by analytics platforms, and the absence of finer instrumentation for events such as QR code display and staying in your area prevent strong generalizations and recommend that findings be read as situated inferences. In addition, the absence of explicit warning of experimentation in the original campaign constitutes a relevant ethical limitation, which should be considered in future applications of the proposed protocol.

Still, precisely because it operates under these restrictions, the case offers an important contribution to the field of communication and applied digital marketing. By examining a real campaign in a peripheral and low-scale context, the article shows that measuring well in these environments depends less on accumulating large volumes of data than on rigorously interpreting limited, contextually marked, and technically framed signals by the platforms. It is

in this displacement that its central contribution lies: to put the local purpose of the interface back at the center of the analysis and to demonstrate that, in markets with low demographics, the quality of the analytical decision depends on the ability to articulate standardized metrics, interface environment and concrete context of use.

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PRODUCTION AND CHARACTERIZATION OF STILL-DISTILLED RUM
PRODUÇÃO E CARACTERIZAÇÃO DE RUM DESTILADO EM ALAMBIQUE
PRODUCCIÓN Y CARACTERIZACIÓN DEL RON DESTILADO EN ALGO



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ABSTRACT

The global rum market was valued at US\$15 billion in 2020 and is projected to reach US\$21.5 billion in 2025 at a compound annual growth rate of 5.5% during the period. This growth expectation is due to the global increase in demand for high-quality, intensely flavored rum (Market Data Forecast, 2020). The rum market in Brazil follows the global trend, registering significant growth in consumption in recent years, driven by a public seeking products with more sophisticated and differentiated flavor profiles (Businesscoot, 2020). Thus, rum distilled in copper stills stands out for its fuller-bodied and more complex flavor compared to rum produced in distillation columns, achieving a prominent position in the market. This scenario motivated this study, which aimed to investigate the production and characterization of rum distilled in copper stills, in accordance with current Brazilian legislation. The raw material used was sugarcane molasses. Fermentation was carried out in a fed-batch system using CA-11 yeast, a commercial strain of *Saccharomyces cerevisiae*. The resulting wine was distilled in a copper still, and rum was produced by diluting the heart fraction of the distillate to 40 °GL. Physicochemical analyses confirmed that the rum produced meets the requirements established by legislation, demonstrating adequate parameters that guarantee its conformity and quality. Furthermore, the product obtained presented a visual aspect, aroma, and flavor characteristic of excellent beverages, demonstrating that the processes adopted were effective in obtaining a well-crafted distillate.

Keywords: Rum. Molasses. Copper Still.

RESUMO

O mercado global de rum foi avaliado em US\$ 15 bilhões em 2020, e deverá atingir US\$ 21,5 bilhões em 2025 a uma taxa de crescimento anual composta de 5,5% durante o período. Esta expectativa de crescimento é devido ao aumento global da demanda por rum de alta qualidade e sabor intenso (Market Data Forecast, 2020). O mercado de rum no Brasil acompanha a tendência global, registrando um expressivo crescimento no consumo nos últimos anos, impulsionado por um público que busca produtos com perfis de sabor mais sofisticados e diferenciados (Businesscoot, 2020). Desse modo, o rum destilado em

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alambique de cobre destaca-se por seu sabor mais encorpado e complexo em comparação ao rum produzido em colunas de destilação, conquistando uma posição de destaque no mercado. Esse cenário motivou a realização deste estudo, que teve como objetivo estudar a produção e caracterização do rum destilado em alambique de cobre, em conformidade com a legislação brasileira vigente. A matéria prima utilizada foi o melaço de cana. A fermentação foi realizada em sistema de batelada alimentada utilizando a levedura CA-11, uma cepa comercial da *Saccharomyces cerevisiae*. O vinho resultante foi destilado em alambique de cobre e o rum foi produzido diluindo-se a fração coração do destilado a 40 °GL. As análises físico-químicas realizadas comprovaram que o rum produzido atende aos requisitos estabelecidos pela legislação, evidenciando parâmetros adequados que garantem sua conformidade e qualidade. Além disso, o produto obtido apresentou aspecto visual, aroma e sabor característicos de bebidas de excelência, demonstrando que os processos adotados foram eficazes na obtenção de um destilado bem elaborado.

Palavras-chave: Rum. Melaço. Alambique de Cobre.

RESUMEN

El mercado mundial del ron se valoró en 15.000 millones de dólares en 2020 y se proyecta que alcance los 21.500 millones de dólares en 2025, con una tasa de crecimiento anual compuesta del 5,5% durante el período. Esta expectativa de crecimiento se debe al aumento global de la demanda de ron de alta calidad y sabor intenso (Market Data Forecast, 2020). El mercado del ron en Brasil sigue la tendencia global, registrando un crecimiento significativo en el consumo en los últimos años, impulsado por un público que busca productos con perfiles de sabor más sofisticados y diferenciados (Businessscoot, 2020). Así, el ron destilado en alambiques de cobre destaca por su sabor más completo y complejo en comparación con el ron producido en columnas de destilación, alcanzando una posición prominente en el mercado. Este escenario motivó el presente estudio, que tuvo como objetivo investigar la producción y caracterización del ron destilado en alambiques de cobre, de acuerdo con la legislación brasileña vigente. La materia prima utilizada fue melaza de caña de azúcar. La fermentación se realizó en un sistema de lotes alimentados utilizando levadura CA-11, una cepa comercial de *Saccharomyces cerevisiae*. El vino resultante se destiló en un alambique de cobre, y el ron se produjo diluyendo la fracción central del destilado a 40 °G. Los análisis fisicoquímicos confirmaron que el ron producido cumple con los requisitos establecidos por la legislación, demostrando parámetros adecuados que garantizan su conformidad y calidad. Además, el producto obtenido presentó un aspecto visual, aroma y sabor característicos de bebidas excelentes, demostrando que los procesos adoptados fueron efectivos para obtener un destilado de alta calidad.

Palabras clave: Ron. Melaza. Alambique de Cobre.

1 INTRODUCTION

1.1 CONCEPTS AND DEFINITIONS

Rum is an alcoholic distillate obtained from sugar cane. It is produced in several subtropical regions of the world, where sugarcane is grown. Although the most well-known rums are from Caribbean countries, rum is also produced in Australia, Fiji, India, Indonesia, Mauritius, Réunion, Sri Lanka, and other countries (Buglass, 2011).

The etymological origin of the word "rum" is uncertain. Some authors suggest that the term derives from "*Saccharum*", the genus of sugarcane (*Saccharum officinarum* L.). Another possibility is that it originates from the word "*rumbustion*", British slang for "great turmoil or uproar". A more likely origin is "*rumbullion*," a term used to describe a beverage boiled from sugarcane stalks. However, both terms were first reported at about the same time as the emergence of the word "rum", which makes it difficult to reach a consensus on its origin (Lieberman, 2010).

Rum is a beverage whose definition and classification are very diverse, varying according to the country or region of the world in which it is produced. Regarding the raw material, its manufacture can be made from sugarcane juice, molasses from the sugar industries or a combination of these. In Brazil, rum is produced from molasses. In the French overseas territories, there are specific distinctions: rum is called "agricultural" when produced from sugarcane juice and "industrial" when made with molasses (Fernández, 2016).

Similarly, the criteria used to classify rum as "white", "golden", "dark", "light", "heavy", etc. vary depending on the place of manufacture. These classifications are directly related to the distillation method, the aging time and the color of the product, which can result either from aging in wooden barrels or from the addition of dyes, or even from a combination of both (Murtagh, 2003).

1.2 THE RUM MANUFACTURING PROCESS

The manufacture of rum comprises the stages of clarifying the molasses, making the must, fermentation, distillation and finally the storage of the product.

Clarification aims to remove gums, waxes and colloidal substances present in molasses, which interfere with the fermentation and distillation stages. This process is carried out with the use of flocculation agents, at a pH between 5.0 and 5.5, at 80 °C, followed by filtration or centrifugation. The clarified molasses is then diluted to a °Brix of 14-16, which is the ideal sugar concentration range for the fermentation stage. Fermentation wort is made from clarified and

diluted molasses, supplemented with nutrients such as ammonium sulfate, vitamins, minerals, cornmeal, and rice bran, among others (Mangwanda, 2021).

From the fermentation stage, the production of rum follows a process similar to that of other beverages derived from sugarcane, brandy and cachaça. Fermentation is carried out with the use of the yeast *Saccharomyces cerevisiae*, which converts the sugars present in the must into ethanol, resulting in a sugarcane wine. Several other compounds are formed in smaller amounts, such as organic acids, methanol, esters, aldehydes, and higher alcohols. Such compounds contribute to the formation of the aroma and flavor of the drink.

After fermentation, the wine is then distilled, obtaining rum. Distillation can be carried out discontinuously, using copper stills, or continuously, by means of distillation columns. Generally, small producers opt for stills, while medium and large distilleries use columns.

In distillation in pot stills, the distillate is collected and separated into three distinct fractions. The first fraction is called the "head", which corresponds to the first condensed vapors and contains high concentrations of alcohol, usually above 60% (v/v). The volume of this fraction represents 1.0% to 2.0% of the volume of the wine, or approximately 10% of the total volume distilled. Next, the fraction called "heart" is distilled, which corresponds to an average of 16% of the volume of the wine, or 80% of the total volume distilled. This is the fraction that will give rise to rum. Finally, the fraction called "tail" or "weak water" is distilled, which corresponds to approximately 3.0% of the total volume of the wine, or 10% of the volume of the distillate. The "head" and "tail" fractions should not be used in the rum production process, as they present undesirable compounds that depreciate the quality of the product. However, these fractions can be mixed and distilled again in a column for the manufacture of fuel alcohol (Souza *et al.*, 2013).

In column distillation of rum, there is no sequential separation of the distillate into fractions. The feeding of wine to the column, the separation of the more volatile components, such as methanol, and less volatile, such as higher alcohols, and the removal of the distillate happen simultaneously and throughout the process.

The product obtained in the distillation stage is diluted until it reaches the alcohol concentration determined by the manufacturer. After this adjustment, the liquid can be subjected to maturation, being stored for a period of 2 to 4 months in inert containers, such as stainless steel, or it can go on to the aging process, where it remains for at least one year in wooden barrels, acquiring unique characteristics of flavor and aroma.

1.3 BRAZILIAN LEGISLATION: STANDARDS OF IDENTITY AND QUALITY OF RUM

In Brazil, the standards of identity and quality of rum are established by Decree No. 6,871, of June 4, 2009. According to this legislation, rum is defined as a beverage with an alcohol content of thirty-five to fifty-four percent by volume, at twenty degrees Celsius, obtained from the simple alcoholic distillate of molasses, or from the mixture of distillates of sugar cane juice and molasses, aged totally or partially in an oak or equivalent wood container, conserving its peculiar sensory characteristics. The product can be added sugars up to a maximum amount of six grams per liter and the use of caramel for color correction is allowed. The coefficient of congeners, which is the sum of the concentration of the substances formed during the manufacturing process, cannot be less than forty or more than five hundred milligrams per hundred milliliters of anhydrous alcohol.

Rum may be called:

- I. Light rum or light rum when the coefficient of congeners of the beverage is less than two hundred milligrams per hundred milliliters in anhydrous alcohol;
- II. Heavy rum or heavy rum when the coefficient of congeners of the beverage is two hundred to five hundred milligrams per hundred milliliters in anhydrous alcohol, obtained exclusively from molasses; e
- III. Aged rum or old rum is a beverage that has been aged, in its entirety, for a minimum period of two years.

1.4 MARKET AND CONSUMER TRENDS

Rum is the second most consumed distilled beverage in the world, with 1.6 billion liters per year, second only to vodka, with 4.5 billion liters (Market Data Forecast, 2020).

Depending on the country where it is produced, rum can be obtained from sugarcane juice, molasses or a mixture of these, in addition to having a diversity of classifications regarding color, flavor and aging time. As for the distillation method, rum falls into two categories: alembic rum, when distilled in copper stills, and column rum, when distilled in distillation columns (Fernández, 2016). Copper pot still distillation provides a drink with a more intense aroma and flavor, while column distillation provides a drink with a milder aroma and flavor.

The global rum market was valued at \$15 billion in 2020, and is expected to reach \$21.5 billion by 2025 at a compound annual growth rate of 5.5% during the period. This growth expectation is due to the global increase in demand for high-quality, intense-tasting rum (Market Data Forecast, 2020). The increase in rum consumption is already consolidated in several countries around the world. India and the United States record strong growth in the premium

rum market (Grand View Research, 2023). Other markets, such as China, Japan, the Philippines, and Australia are also expected to have a significant impact on the market growth due to the large consumer base and demand for quality rum, with a fuller taste (Market Data Forecast, 2020).

The rum market in Brazil is in line with the global trend, with a notorious increase in consumption in recent years. This increase is due to a growing group of consumers who are looking for products in a higher category, with a striking and differentiated flavor profile (Businesscoot, 2020). In this context, alembic rum, because it has a richer flavour than rum produced using distillation columns, is expected to occupy a prominent position in the market.

The growing consumer interest in alembic rum and the low supply of this product in the domestic market represent an opportunity to generate revenue for small and medium-sized producers of cachaça and brandy throughout the country, who use distillation in copper stills in the manufacture of their products. The equipment already installed and the experience acquired in the manufacture of cachaça and brandy greatly favor the production of alembic rum by these producers.

Another important factor is that the manufacture of rum can contribute to optimizing the operation and use of the productive capacity of a mill that already produces cachaça and/or brandy. Sugar cane, the raw material for cachaça and brandy, deteriorates quickly and cannot be stored. Therefore, the production of these beverages occurs only during the sugarcane harvest period, underusing the machinery and increasing maintenance costs. The manufacture of rum, in addition to increasing the company's product portfolio and revenue, allows the mill to operate practically all year round, since molasses, the raw material for rum, can be stored for long periods. In this way, it is possible to produce cachaça during the harvest, and rum in the sugarcane off-season.

Therefore, the study of rum manufacturing, in addition to contributing to technical and scientific knowledge, also values the economy and sustainable development of sugarcane-producing regions. The synergy between rum, cachaça and brandy optimizes production and increases the economic sustainability of the mills, which adds even more value to this study.

2 METHODOLOGY

2.1 RAW MATERIAL

The raw material used for the manufacture of rum was molasses, whose physicochemical characterization was carried out through the analysis of Brix, Pol, Purity and Total Reducing Sugars (ART), according to the methodology described by Caldas (2012).

2.2 FERMENTATION MUST

The must consisted of eight liters of molasses diluted to 16° Brix and supplemented with forty grams (5g/L) of corn meal. To minimize bacterial contamination during fermentation, the pH was adjusted to values between 4.0 and 4.5 by adding citric acid.

2.3 YEAST

For the preparation of the yeast, the selected yeast CA11, a commercial strain of *Saccharomyces cerevisiae*, was used.

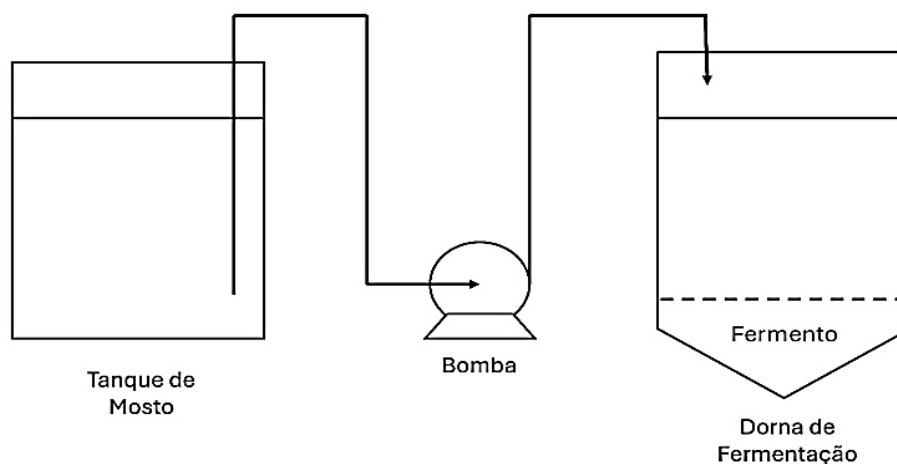
Initially, eight grams of the yeast were hydrated in 250 mL of water for 15 minutes. Subsequently, 250 mL of diluted molasses was added and supplemented, as specified in item 2.2. Once the Brix of this mixture was halved, an additional 500 mL of molasses was incorporated. When the Brix of the new mixture reached 4%, the yeast was transferred to the fermentation vat.

2.4 FERMENTATION

Fermentation was conducted in a fed-batch system, as illustrated in Figure 1.

Figure 1

Fed batch fermentation scheme



Source: Authored by the author.

The process began with the introduction of the yeast into the vat, which was then filled with the fermentation wort, prepared as described in item 2.3. The peristaltic pump was configured to fill the vessel in a period of five hours, a time commonly adopted in distilleries. After the end of filling, the pump was turned off, and the fermentation evolution was monitored by measuring the Brix of the fermentation medium, at twelve-hour intervals, using a Brix saccharimeter. Fermentation was considered complete when the Brix of the must remained constant between two consecutive measurements.

2.5 DISTILLATION

The distillation was carried out in a copper still with a useful volume of eight liters, heated over direct heat and equipped with a dephlegmator (Figure 2). The separation of the head, heart and tail fractions was carried out according to the estimated volume of the distillate, calculated according to the methodology reported by Chaves (2007):

$$V_{\text{dest}} = V_{\text{vinho}} * (\text{Brix}_{\text{mosto}} - 2)/100 \quad (1)$$

Where:

V_{dest} = Estimated volume of distillate, in liters;

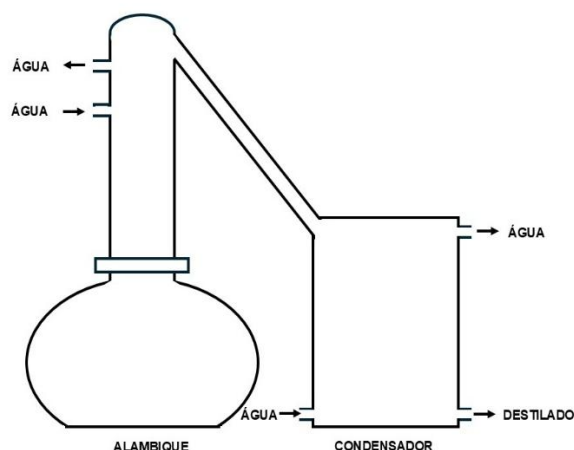
V_{vinho} = Volume of wine (fermented must), in liters;

$\text{Brix}_{\text{mosto}}$ = Concentration of soluble solids of the wort, before fermentation.

According to this method, the head and tail fractions each correspond to ten percent and the heart fraction to eighty percent of the estimated volume of the distillate.

Figure 2

Copper still equipped with dephlegmator and condenser



Source: Authored by the author.

2.6 ADJUSTMENT OF ALCOHOL CONTENT

According to current legislation, rum can have an alcohol content ranging from 35 to 54 °GL. In this project, it was decided to produce a drink with 40 °GL, as this is a very common value in rums available on the market.

To obtain the rum with the desired alcohol content, the heart fraction of the distillate was diluted with a volume of water calculated by the solution dilutions equation (Brown et al., 2005), as described below:

$$C_1 * V_1 = C_2 * V_2 \quad (2)$$

Where:

C1 = Alcohol content of the heart fraction;

V1 = Volume of the heart fraction;

C2 = Alcohol content of the rum;

V2 = Volume of rum with alcohol content C2.

2.7 REVIEWS

The quality control of the rum produced was carried out according to the standards of identity and quality established in Normative Instruction No. 15/2011, of MAPA. Analyses were performed to determine the alcohol content and concentrations of volatile acidity, aldehydes, higher alcohols, esters, furfural, methanol and the congener coefficient. The alcohol content (% by volume) was initially determined by measuring the density of the sample, using a

pycnometer. Next, the relative density at 20°C was converted into alcohol content, using a conversion table, according to the official method of the Adolfo Lutz Institute (2008).

The other analytical parameters were determined using a Shimadzu gas chromatograph, model QP-2010 Pro, with flame ionization detector (GC-FID), Stabilwax-DA capillary column and automatic injection system of 1.0 microliter sample.

3 RESULTS AND DISCUSSION

3.1 MOLASSES

The result of the molasses quality control analyses is shown in Table 1. The results of all parameters are within the characteristic ranges of molasses considered to be of good quality (Mangwanda, 2021).

The origin of the molasses exerts a significant influence on the quality of the rum. This was proven in experiments that used beet molasses in the production of the drink, demonstrating that it was not possible to obtain the same aroma profile present in rum made from sugarcane molasses (Arroyo, 1948). Fresh sugarcane molasses, with low viscosity and high total sugar content, such as the one used in this study, is ideal for the production of rum, providing superior quality aromas and flavors (Delevante, 2004).

Table 1

Molasses quality control parameters

Parameter	(%) w/m
Brix	77,5
Pol	44,34
ART	63,55
Purity	57,21

Source: Authored by the author.

3.2 MUST PREPARATION AND FERMENTATION

To obtain the wort at the desired Brix concentration, 1,500 mL of molasses were diluted in 6.5 L of water. These proportions were calculated through a mass balance, using as calculation bases the Brix of molasses (Table 1) and the volume and Brix intended for the must. After dilution of molasses and supplementation with forty grams of cornmeal, eight liters of must with a concentration of 16 °Brix and an initial pH of 5.64 were obtained. To reduce the growth of contaminating bacteria, citric acid was gradually incorporated until the pH of the wort was adjusted to the range of 4.0 to 4.5. At the end of the addition of 10 grams of citric acid, the pH was stabilized at 4.38 and therefore considered suitable for fermentation.

Fermentation was carried out in a fed-batch system, as illustrated in Figure 1. Initially, a liter of yeast was placed in the vat. Then, the pump was turned on, and the fermentation time began to count. The pump flow was programmed to add the eight liters of wort to the vessel over a five-hour period. The evolution of fermentation was followed by measuring the concentration of sugars in the fermentation medium, at twelve-hour intervals, using a Brix saccharimeter. The results are presented in Table 2.

Table 2

Concentration of sugars as a function of fermentation time

Fermentation time (h)	Brix (%)
0	16
12	14,5
24	12
36	9
48	6
60	3
72	3

Source: Authored by the author.

Alcoholic fermentation is considered complete when all of the fermentable sugar is consumed, resulting in a Brix value of zero. However, molasses may contain different proportions of non-fermentable sugars, those that are not metabolized by yeast. As a consequence, at the end of the fermentation of these molasses, the Brix will not reach zero. Thus, the process is considered to be finished when the value of the Brix remains stable for an extended period. In this study, as no reduction in Brix was observed between 60 and 72 hours, fermentation was considered finished after 60 hours, and the resulting wine went to the distillation stage.

3.3 DISTILLATION AND ADJUSTMENT OF ALCOHOL CONTENT

The distillation process has a significant impact on the characteristics of the rum and can be carried out in copper stills or distillation columns. The first method results in a more aromatic drink with a pronounced flavor, while the second produces a rum with a lower concentration of congeners, giving it a milder aroma and flavor. Both systems have variations, both in equipment and in the mode of operation. In this study, aiming at the production of a more full-bodied rum and in line with the global consumption trend, it was decided to distill in a copper still.

Initially, the estimated volume of the distillate was calculated, according to the methodology described in item 2.5:

$$V_{\text{dest}} = V_{\text{vinho}} * (\text{Brix}_{\text{mosto}} - 2)/100 \quad (3)$$

$$V_{\text{dest}} = 8,0 * \frac{(16-2)}{100} = 1,12 \text{ litros ou } 1220 \text{ mL} \quad (4)$$

According to this method, the "head" and "tail" fractions correspond to 10% each, while the "heart" fraction represents 80% of the volume of the distillate. Therefore, during the distillation process, the first 122 mL collected were classified as the "head" fraction and discarded. Then, the subsequent 976 mL were considered as the "heart" fraction and properly stored. Distillation was interrupted after this step, since the "tail" fraction had no applicability in this study.

The alcohol content of the "heart" fraction was measured with a Gay-Lussac alcoholmeter, and the result was 45 °GL. To obtain rum with an alcohol content of 40 °GL, the heart fraction was diluted with a volume of water calculated by the solution dilutions equation (Brown *et al.*, 2005), as described in item 2.6. Starting from 976 mL of a heart fraction with an alcohol content of 45 °GL, 122 mL of water were added, thus obtaining 1098 mL of rum at 40 °GL.

3.4 PHYSICOCHEMICAL ANALYSES

Table 3 presents the results of the physicochemical analyses of the rum produced in this study. The values obtained for all the parameters analyzed are within the limits established by the Brazilian legislation.

Table 3

Analytical parameters of rum

Parameter	Value	Minimum threshold	Maximum limit
Alcohol content, in %, in v/v, at 20 °C	39,1	35	54
Volatile acidity, in acetic acid, in mg/100 mL of anhydrous alcohol	10,6	-	150
Superior alcohol (sum of n-propyl alcohol, isobutyl alcohol and iso amyl alcohol), in mg/100 mL of anhydrous alcohol	96,2	-	260
Aldehydes, in acetic aldehyde, in mg/100 mL anhydrous alcohol	17,6	-	20
Esters, in ethyl acetate, in mg/100 mL anhydrous alcohol	25,4	-	200
Sum of furfural and hydroxymethylfurfural, in mg/100 mL of anhydrous alcohol	-	-	5
Congener coefficient, in mg/100 mL of anhydrous alcohol	149,8	40	500

Methyl alcohol, in mg/100 mL anhydrous alcohol	3,04	-	200
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Source: Decree No. 6,871/2009, I.N. Map No. 15/2011

4 CONCLUSION

The methodology used in this study allowed a detailed analysis of the production and characterization of rum distilled in copper stills, in accordance with the current Brazilian legislation. The characterization of the molasses used provided essential information about its composition and quality, ensuring its suitability to be used as raw material.

The physicochemical analyses carried out proved that the rum produced meets the requirements established by the legislation, evidencing adequate parameters that guarantee its compliance and quality. In addition, the product obtained presented a visual aspect, aroma and flavor characteristic of excellent beverages, demonstrating that the processes adopted were effective in obtaining a well-prepared distillate.

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ADAPTIVE ARCHITECTURE IN EXTREME ENVIRONMENTS: VERNACULAR TECHNIQUES AND SUSTAINABILITY IN AMAZONIAN RIVERSIDE COMMUNITIES

ARQUITETURA ADAPTATIVA EM AMBIENTES EXTREMOS: TÉCNICAS VERNACULARES E SUSTENTABILIDADE NAS COMUNIDADES RIBEIRINHAS AMAZÔNICAS

ARQUITECTURA ADAPTATIVA EN AMBIENTES EXTREMOS: TÉCNICAS VERNÁCULAS Y SOSTENIBILIDAD EN LAS COMUNIDADES RIBEREÑAS AMAZÓNICAS



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ABSTRACT

This article discusses the construction system of communities in floodplain regions and over water, analyzing vernacular architecture, the form of houses, their structure, enclosures, and the cultural relationship embedded in this process, especially in the Brazilian Amazon, while drawing parallels with international works. It introduces the historical issues of dwelling on and within floodplains. Therefore, it examines the relationship between riverside populations, housing, and the environment. The methods are based on a literature review and field study

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with site visits. The study identifies traditional stilt houses alongside floating constructions. Another relevant aspect in the Brazilian Amazon is that houses over the river accommodate not only domestic space, but also productive activities, commerce, transportation, and social practices. It is observed that riverside communities employ local materials, reuse components, and promote ecological integration, making these constructions practical examples of empirical sustainability.

Keywords: Riverside House. Stilt Houses. Floating Structures. Sustainability.

RESUMO

Este artigo discute o sistema construtivo das comunidades em regiões das várzeas e sobre as águas, analisando a arquitetura vernacular, a forma das casas, a sua estrutura, vedações e a relação cultural deste processo, em especial da Amazônia brasileira, e faz paralelos a obras internacionais. Introduz as questões históricas do habitar sobre e as suas várzeas. Portanto, discute a relação entre os ribeirinhos, a moradia e o meio ambiente. Os métodos partem da revisão da literatura e estudo de campo com visitas. O estudo identifica as moradias palafíticas tradicionais às construções flutuantes. Outro aspecto relevante na Amazônia Brasileira é que as casas sobre o rio abrigam não apenas o espaço doméstico, mas também as atividades produtivas, o comércio, o transporte e as práticas de sociabilidade. Observa-se que as comunidades ribeirinhas aplicam materiais locais, a reutilização de componentes e a integração ecológica fazem dessas construções exemplos práticos de sustentabilidade empírica.

Palavras-chave: Casa Ribeirinha. Palafitas. Flutuante. Sustentabilidade.

RESUMEN

Este artículo discute el sistema constructivo de las comunidades en regiones de várzeas y sobre el agua, analizando la arquitectura vernácula, la forma de las viviendas, su estructura, cerramientos y la relación cultural de este proceso, especialmente en la Amazonía brasileña, y establece paralelos con obras internacionales. Introduce las cuestiones históricas del habitar sobre y en las llanuras de inundación. Por lo tanto, analiza la relación entre las comunidades ribereñas, la vivienda y el medio ambiente. Los métodos se basan en la revisión de la literatura y en el estudio de campo con visitas. El estudio identifica las viviendas palafíticas tradicionales junto con las construcciones flotantes. Otro aspecto relevante en la Amazonía brasileña es que las casas sobre el río albergan no solo el espacio doméstico, sino también actividades productivas, comercio, transporte y prácticas de sociabilidad. Se observa que las comunidades ribereñas emplean materiales locales, la reutilización de componentes y la integración ecológica, lo que convierte a estas construcciones en ejemplos prácticos de sostenibilidad empírica.

Palabras clave: Vivienda Ribereña. Palafitos. Flotante. Sostenibilidad.

1 INTRODUCTION

The history of dwelling on water is, above all, the history of the human capacity for adaptation. Since ancient times, communities around the world have developed ways of living in aquatic or seasonally floodable environments, responding with ingenuity to the conditions imposed by the natural environment. In each geographical context, water presents itself not only as a physical obstacle, but also as a symbolic, cultural, and spiritual element — an essential component of the relationship between society and territory.

The first records of constructions on water date back to the Neolithic period. Archaeological excavations in Alpine regions of Europe — especially in Switzerland and Italy — have revealed the presence of lake villages erected on wooden stilts, dating to around 5,000 B.C. These dwellings, known as *pile dwellings* or stilts, consist of platforms suspended above the surface of lakes, accessed by walkways and protected from flooding and animals (Anderson, 2014).

Similarly, Southeast Asian civilizations, such as those of Indonesia, Thailand, and the Philippines, developed stilt buildings on the banks of rivers and deltas, using bamboo, teak, and other light woods. In these contexts, the technique was not only a response to humidity or floods, but also a way of occupying mobile territories, where the boundary between land and water is constantly transformed.

On the American continent, palatines appear in different cultural expressions. In South America, the most notable example is that of the Amazonian communities, which for centuries have used wood as a structural basis for elevated or floating houses, adapted to variations in river levels. In Chile, the *stilt houses* of Chiloé have become architectural icons, combining traditional construction knowledge with a unique aesthetic (Oliveira Junior, 2009; Anderson, 2014). These diverse experiences — European, Asian or South American — converge in the use of wood as a mediator between the natural environment and the inhabited space. Its lightness and versatility make it possible to face water cycles without disrupting the ecological balance, giving rise to a constructive tradition that, in many places, remains alive today.

The relationship between human beings and water transcends the functional aspect. In many cultures, water is perceived as the origin of life, a source of purification, and a symbol of transformation. This imaginary permeates the way of building and living with her. In the Amazon, for example, the river is not only a natural resource or transport route, but an extension of the domestic space itself. As Oliveira Junior (2022, p. 37) observes, "the house is a continuation of the canoe, and the river is the street of everyday life". This conception transforms the riparian habitat into a form of existence deeply integrated into the aquatic environment.

Figure 1*Canoe house*

Source: Diego Peres, Arthur Castro: Secom

The symbology of water is also manifested in other traditions. In Southeast Asian communities, proximity to rivers is associated with spiritual values, while in European coastal cities dominance over the sea has historically been linked to prosperity and territorial expansion. In all of these cases, the act of building on or next to water reflects a balance between reverence and pragmatism—between the need for protection and the recognition of water as a constitutive part of the territory.

This symbolic dimension explains, in part, the persistence of aquatic dwellings even in the face of urban modernization. Living on water carries a logic that is not limited to functionality: it expresses a philosophy of coexistence with the environment, in which architecture is an extension of the natural cycle and not its negation.

2 OBJECTIVE

The objective of this article is to study the vernacular construction techniques in the Amazon and to make parallels with international works.

3 METHODOLOGY

This article is based on a literature review and field study carried out in riverside communities of the Solimões River floodplains, particularly in Manacapuru (Amazonas).

The literature review covered academic publications on construction techniques on water in the world, with an emphasis on experiences in the Netherlands, Canada, and Southeast Asia, as well as literature on Amazonian vernacular architecture, often already developed by the

author himself in his master's dissertation (OLIVEIRA JUNIOR, 2009) and doctoral thesis (OLIVEIRA JUNIOR, 2022).

The field study consisted of visits, direct observation and photographic documentation of the dwellings, emphasizing: constructive typologies (stilt houses, floating houses, stevedoring houses), materials used (native wood species), traditional construction processes, and the relationship between spatial organization and ways of life. Semi-structured interviews with residents and local builders allowed us to understand the transmission of knowledge and cultural practices associated with the constructions.

The comparative analysis established parallels between Amazonian technical solutions and international experiences, highlighting patterns of environmental adaptation and sustainability. This study also benefited from the author's previous research presented to the International Seminar on Research in Urbanism — SIU (OLIVEIRA; MEIRELLES; FEHR, 2020).

4 LITERATURE REVIEW

4.1 CONSTRUCTION TECHNIQUES ON THE WORLD'S WATERS

The relationship between architecture and the aquatic environment is not exclusive to the Amazon. In various parts of the world, communities and professionals have developed wooden construction solutions for housing in areas subject to floods, tides and extreme climatic variations. These experiences, although diverse in scale and technology, share the same principle: the adaptation of the built space to the water cycle.

International studies allow us to identify a conceptual evolution that goes from traditional stilt houses to floating constructions and, more recently, to amphibious housing, which combines conventional foundation techniques with controlled flotation systems.

According to Anderson (2014), it is possible to classify constructions on water into four major categories, according to the degree of interaction with the liquid medium:

1. Terps (raised embankments) – dwellings erected on earthen platforms or artificial embankments, common in coastal regions of the Netherlands and northern Europe;
2. Houses on stilts (stilts)—supported by foundations driven into the submerged soil, typical of wetlands and river deltas;
3. Houseboats – buildings that rest entirely on flotation systems, usually composed of rafts, concrete coffins or metal drums;
4. Amphibious houses – which remain supported on fixed foundations, but are able to rise and return to the original level according to the variation of the water level.

This typology allows us to understand the diversity of strategies adopted around the world, despite all of them present in the Amazonian regions surveyed. Each model expresses a specific response to environmental, cultural and technological conditions, but they all share the same search: to ensure safe and continuous habitability in environments subject to water instability.

4.2 NOTABLE EXPERIENCES ON THE INTERNATIONAL SCENE

Several countries have stood out in the development of projects aimed at housing on water. Just to name a few examples, the Netherlands, Canada and Southeast Asia present representative approaches, which combine tradition, innovation and sustainability.

- **Netherlands: amphibious architecture and aquatic urbanism**

The Netherlands is a world reference in amphibious architecture and resilient urbanism. Due to its flat topography and the constant threat of flooding, the country has historically developed advanced water control techniques and adapted housing. The **Maasbommel project**, designed by Dura Vermeer in partnership with **Factor Architecten**, is considered the world's first amphibious housing development. Completed in 2005, the development consists of 46 homes built in laminated timber, set on floating foundations of lightweight concrete. In periods of flooding, the houses rise gently, guided by metal pillars, returning to their original position when the water level drops (Anderson, 2014).

Figure 2

Amphibious houses – Maasbommel – Netherlands



Source: Dura Vermeer, 2006.

Another notable example is the **IJburg district** in Amsterdam, planned as an urban sprawl on the IJmeer lake. The project combines flotation techniques with principles of sustainable urbanism, employing engineered timber and flexible anchoring systems. According

to Anderson (2014), these experiences demonstrate the feasibility of large-scale amphibious urbanism, in which water is no longer seen as a threat and is integrated into the public space.

- **North America: Amphibious Resilience and Retrofit**

In North America, the highlight is the **Buoyant Foundation Project (BFP)**, developed by researcher **Elizabeth English** at the University of Waterloo, Canada. The project came about in response to Hurricane Katrina, which devastated New Orleans in 2005, destroying thousands of wooden homes. English (2009) proposed an amphibious retrofit system that allows the conversion of existing residences into floating buildings. The solution is based on a set of polyethylene floats installed under the foundation, coupled to a system of vertical guides. During a flood, the house rises gently and returns to the ground without sustaining structural damage.

Lac's house was renovated and floated during the 2018 seasonal flood – Vietnam – Mekong River Delta

Figure 3



Source: <https://www.buoyantfoundation.org/vietnam-amphibiation-in-the-mekong-river-delta>

- **Southeast Asia: Continuity of the Stilt Tradition**

Southeast Asia represents perhaps the most continuous and widespread form of dwelling on water. Countries such as Vietnam, Cambodia and Indonesia maintain extensive stilt houses built entirely of wood and bamboo. In these regions, the technique is not limited to housing: schools, temples, markets and even entire cities — such as **Kampong Ayer**, in Brunei — are built on stilts. The construction system is simple and efficient: hardwood piles driven into the floodable soil support light platforms on which bamboo walls and straw or wooden roofs are erected.

Figure 4

Kampong Ayer, Brunei, known as the Venice of the East



Source: Taz Zaidi.

According to Anderson (2014), the durability of these structures depends on constant maintenance and periodic replacement of parts in contact with water. Although rudimentary, these buildings have sophisticated constructive logic: flexibility, natural ventilation and total integration into the ecosystem. Such principles have even inspired contemporary sustainable architecture projects in the region, such as those of **Vo Trong Nghia Architects** in Vietnam, which reinterpret the stilt tradition with modern techniques of laminated wood and treated bamboo.

4.3 THE FORMATION OF RIVERINE COMMUNITIES IN THE AMAZON

In the Amazonian context, water habitation is a direct result of the ecological and economic relationship between man and the river. In the case of the populations living on the banks of the Solimões, Negro and Amazonas, they have developed forms of settlement that seek to keep up with the annual floods and ebbs, adjusting their way of life to the rhythm of the waters. Wood, abundant and diversified, has become the main construction material, giving rise to typologies that vary according to the degree of flooding and the type of soil. As Oliveira Junior (2009) points out, the stilt, floating and stevedoring houses form an adaptive system that reflects both the material culture and the environmental intelligence of the riverside dwellers. These constructions are erected collectively, in joint efforts that reinforce community bonds and the exchange of knowledge.

Meirelles *et al.* (2018) point out that, in contemporary riverside cities, such as Manacapuru and Coari, traditional typologies still persist, even with the introduction of industrialized materials, as these meet the conditions of the terrain and the variations in river levels.

In addition to responding to environmental demands, riverside architecture reveals a specific social structure. The houses on the river shelter not only the domestic space, but also productive activities, commerce, transportation and sociability practices. The built environment extends into the liquid space, forming what Oliveira Junior (2022) describes as a "living landscape", where inhabiting and nature coexist in an organic way.

4.4 THE ROLE OF WOOD IN WATER CROP

The recurring presence of wood in aquatic constructions throughout history is no coincidence. It is a material that brings together unique characteristics for this type of environment: **availability**, lightness, flexibility, tensile strength and a good relationship between weight and load capacity. In addition, wood offers ease of repair and replacement — an essential aspect in contexts where the wear and tear caused by humidity and aquatic organisms is constant.

In the Amazon, the species traditionally used — such as itaúba, angelim, acacu and maçaranduba — are chosen for their natural durability and local availability (Hermes, 2014). Over time, wood consolidates itself as a symbolic mediator between man and water: it is the element that allows us to be on the river without moving away from it, to float without breaking the bond with the land. Even in the most technological experiences — such as contemporary amphibious houses — the choice of wood carries this ancestral heritage, associating lightness and resistance, nature and culture.

The historical study of living on water, therefore, shows a remarkable constancy: regardless of the time or the continent, wood remains the material that translates the human search for balance with the liquid environment. This permanence attests not only to the technical effectiveness of this resource, but also to its role as a cultural language, capable of uniting tradition and innovation around the same principle: living with water, not against it.

4.5 RIVERINE VERNACULAR ARCHITECTURE IN THE AMAZON

The vernacular architecture of the Amazon represents one of the richest expressions of the interaction between culture and nature. It is an architectural production that does not impose

itself on the environment, but develops from it, responding to variations in the water regime, the availability of materials and the social organization of communities.

On the banks of the great Amazonian rivers, wood constitutes the physical and symbolic foundation of this relationship, acting as a mediator between man and the aquatic environment. Each dwelling is, at the same time, shelter, workshop, viewpoint and extension of the landscape.

The shape of the riverside dwellings is a direct result of environmental conditions and the accumulated experience of local populations. According to Oliveira Junior (2009), these constructions translate an "empirical ecological knowledge", transmitted orally and improved for generations, which guides decisions about the place of implantation, the type of foundation and the structural proportions. In general, the riverside house is light, demountable and adaptable to floods — qualities that guarantee both the survival and cultural permanence of the communities.

The most widespread typology is the **stilt house**, supported by wooden stakes driven into the floodable soil. The raised floor allows the house to remain above the water level during the flood period. Its structure, composed of spikes, beams and boards, is simple, modular and built with hand tools, favoring maintenance and reconstruction when necessary.

Figure 5

Stilt house - Manacapuru – AM



Source: Jair Oliveira.

Other variations include **houseboats**, erected on rafts or hollow wooden logs, and **stevedoring houses**, common in lowland areas, partially supported and partially suspended. They all share the same logic: to follow the water cycle without resisting it (Meirelles *et al.*, 2018).

Figure 6*Floating house – Fishing lake – Manacapuru – AM*

Source: Jair Oliveira.

4.6 MATERIALS AND CONSTRUCTION SYSTEMS IN WOOD FROM THE AMAZON

The predominant material is still native woods, used in all parts of the building: foundation, structure, fence and roof. The species used vary according to the region and local availability. Among the most common, the "itaúba (*Mezilaurus itauba*), the red angelim (*Dinizia excelsa*), the acapu (*Vouacapoua americana*), the andiroba (*Carapa guianensis*) and the maçaranduba (*Manilkara huberi*) stand out, recognized for their durability and natural resistance to humidity" (Hermes, 2014).

The construction follows a predominantly artisanal process, carried out in a community collective effort. This practice reinforces social ties and keeps the transmission of technical knowledge alive. Hermes (2014) observes that the construction method is rational and efficient: "houses can be disassembled, transported and assembled with the same set of materials", which ensures mobility in the face of floods.

From a structural point of view, the traditional Amazonian stilt house is based on pillars driven directly into the clay soil, on which the sleepers and the plank floor rest. The walls can be made of wood or woven straw, and the roof, with gables, is traditionally covered with buriti and babassu straw – they are replaced by metal tiles and are now more common. This technical simplicity, far from representing precariousness, translates a refined constructive logic, adjusted to the environment and the economy of available means.

4.7 ENVIRONMENTAL LOGIC AND THE WATER CYCLE

Living on the banks of the Amazon rivers means accepting the alternation between periods of flood and ebb as part of daily life. This constant oscillation requires constructive

solutions that do not oppose nature, but that accompany it. Meirelles et al. (2018) point out that riverside populations living at lower levels face months of isolation during floods, when access is only by canoe. The house, therefore, needs to assume multiple functions — housing, work shelter, warehouse, and even dock.

Figure 7

Two-story floating house and maromba (deposit in periods of drought and stable in periods of flood) Manacapuru – AM



Source: Jair Oliveira.

The observation of Oliveira, Meirelles and Fehr (2020), in a study presented to the International Seminar on Research in Urbanism (SIU), is instructive: "the floating houses of the Solimões River floodplain configure adaptive architectures in constant negotiation with the water landscape". The water level determines the type of foundation, the access system and even the internal organization of the spaces. This dynamic character makes riverside architecture an example of resilient design, in which construction is an extension of the ecosystem.

The notion of the "water cycle" structures not only the physical space, but also the way of life of the communities. The time to build, fish, plant or move depends on the tides and the regimes of the rivers. Architecture, therefore, is not static: it is a temporal and cyclical expression of the relationship between man and the environment. For the riverside dweller, the house is not only a physical shelter: it is also a space for sociability, work and culture, as Fraxe (2000) argues. The construction involves the community in collective efforts, where knowledge is shared and solidarity reinforces the collective bond. This social dimension gives architecture a participatory and pedagogical character. According to Oliveira Junior (2009), "the house is the

center of the social landscape and the river, the public space par excellence". Everyday life unfolds between land and water, and the act of building is also the act of belonging.

Wood, in this context, assumes a symbolic role. It carries the memory of the forest and the ancestral knowledge of the management of available resources. Its texture, smell and sound are part of the sensory experience of living, giving identity and cultural continuity to riverside communities. Amazonian architecture, therefore, goes beyond the technical domain: it is a language that translates a way of existing in harmony with the liquid territory. As Oliveira Junior (2022) observes, understanding this architecture means understanding an ethics of coexistence with the environment — a wisdom that manifests itself not only in technique, but in the very way of living.

Hermes (2014) reinforces that riverside dwellings anticipate central principles of modern sustainable architecture: the efficient use of resources, community self-construction, structural reversibility, and climate adaptability. Recent academic and institutional projects, inspired by these models, have been proposing prefabricated modular systems in engineered wood for regions of difficult access, combining local tradition with new construction technologies (Hermes, 2014; Oliveira Júnior, 2009, 2022).

5 FINAL CONSIDERATIONS

This set of practices, materials, and values makes riverside vernacular architecture an example of how tradition can offer concrete answers to contemporary challenges. Far from representing an obsolete model, it inspires new design possibilities, capable of articulating technology, culture and sustainability.

Sustainability, often treated as a contemporary concept, is already inscribed in the logic of Amazonian vernacular architecture. The use of local materials, minimal waste generation, reuse of components and ecological integration make these constructions practical examples of empirical sustainability. Thus, Amazonian vernacular architecture reveals itself not as a vestige of an artisanal past, but serves as a support and concrete reference for the development of sustainable contemporary solutions. However, it is important to note that, in this context, the term *sustainability* is closer to the notion of survival capacity than to the concept widely disseminated by the so-called *green marketing*, often associated with merely promotional strategies.

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**LETTER FROM A YOUNG SCIENTIST: IT IS INHERENT TO HUMANS TO
DEPART – SCIENCE, HUMANITIES, AND THE IMPASSE OF RETURN**

**CARTA DE UMA JOVEM CIENTISTA: É PRÓPRIO DO HUMANO SAIR –
CIÊNCIA, HUMANIDADES E O IMPASSE DO RETORNO**

**CARTA DE UNA JOVEN CIENTÍFICA: ES PROPIO DEL SER HUMANO PARTIR
– CIENCIA, HUMANIDADES Y EL IMPASSE DEL RETORNO**



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ABSTRACT

This essay, presented in the form of a letter, proposes a critical reflection on the limits of biological reductionism in contemporary science, taking as its starting point the need to rearticulate different forms of knowledge. Based on a formative trajectory situated in the field of health sciences, the author questions the predominance of a technical-productivist logic that tends to privilege already stabilized answers, often at the expense of formulating questions. This shift is not trivial, as it contributes to the impoverishment of scientific reflection and widens the gap between science and society. It is in this context that the movement toward the humanities appears less as a rupture and more as an attempt at epistemological and formative expansion, albeit marked by persistent resistance. Throughout the text, references from philosophy, literature, and the history of science are mobilized to challenge the persistence of a mechanistic and dualistic matrix, historically associated with modern thought, and its effects on the fragmentation of knowledge. At the same time, it is argued that many contemporary initiatives aimed at humanizing science end up being limited to compliance with normative frameworks, without implying a deeper transformation of scientific practices. In this scenario, literature is presented as a privileged space for the exercise of critical reflection, insofar as it enables engagement with dimensions of human experience that escape strictly technical logic.

Keywords: Science. Humanities. Reductionism. Interdisciplinarity. Scientific Education.

RESUMO

Este ensaio, apresentado em forma de carta, propõe uma reflexão crítica sobre os limites do reducionismo biológico na ciência contemporânea, tomando como ponto de partida a necessidade de rearticular diferentes formas de conhecimento. Partindo de uma trajetória formativa situada no campo das ciências da saúde, a autora interroga a predominância de uma lógica técnico-produtivista que tende a privilegiar respostas já estabilizadas, muitas

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vezes em detrimento da formulação de perguntas. Esse deslocamento não é trivial, pois contribui para o empobrecimento da reflexão científica e amplia a distância entre ciência e sociedade. É nesse contexto que o movimento em direção às humanidades aparece menos como ruptura e mais como tentativa de ampliação epistemológica e formativa, ainda que atravessada por resistências persistentes. Ao longo do texto, referências da filosofia, da literatura e da história da ciência são mobilizadas para tensionar a permanência de uma matriz mecanicista e dualista, historicamente associada ao pensamento moderno, e seus efeitos na fragmentação do conhecimento. Ao mesmo tempo, argumenta-se que muitas das iniciativas contemporâneas de humanização da ciência acabam se restringindo ao cumprimento de normativas, sem que isso implique uma transformação mais profunda das práticas científicas. Nesse cenário, a literatura é apresentada como um espaço privilegiado para o exercício da reflexão crítica, na medida em que possibilita o contato com dimensões da experiência humana que escapam à lógica estritamente técnica.

Palavras-chave: Ciência. Humanidades. Reduccionismo. Interdisciplinaridade. Formação Científica.

RESUMEN

Este ensayo, presentado en forma de carta, propone una reflexión crítica sobre los límites del reduccionismo biológico en la ciencia contemporánea, tomando como punto de partida la necesidad de rearticular diferentes formas de conocimiento. A partir de una trayectoria formativa situada en el campo de las ciencias de la salud, la autora cuestiona la predominancia de una lógica técnico-productivista que tiende a privilegiar respuestas ya estabilizadas, muchas veces en detrimento de la formulación de preguntas. Este desplazamiento no es trivial, ya que contribuye al empobrecimiento de la reflexión científica y amplía la distancia entre ciencia y sociedad. Es en este contexto que el movimiento hacia las humanidades aparece menos como una ruptura y más como un intento de ampliación epistemológica y formativa, aunque atravesado por resistencias persistentes. A lo largo del texto, referencias de la filosofía, la literatura y la historia de la ciencia son movilizadas para tensionar la permanencia de una matriz mecanicista y dualista, históricamente asociada al pensamiento moderno, y sus efectos en la fragmentación del conocimiento. Al mismo tiempo, se argumenta que muchas de las iniciativas contemporáneas de humanización de la ciencia terminan restringiéndose al cumplimiento de normativas, sin que ello implique una transformación más profunda de las prácticas científicas. En este escenario, la literatura se presenta como un espacio privilegiado para el ejercicio de la reflexión crítica, en la medida en que posibilita el contacto con dimensiones de la experiencia humana que escapan a la lógica estrictamente técnica.

Palabras clave: Ciencia. Humanidades. Reduccionismo. Interdisciplinariedad. Formación Científica.

1 INTRODUCTION

1.1 IT IS CHARACTERISTIC OF THE HUMAN WANTING TO LEAVE AND OF SCIENCE, TO RELEARN THIS GESTURE

Like so many other scientists, what first moved me was the desire to understand the human being from its biological dimension. I started with anatomy; And when it no longer offered me enough answers, I moved on to smaller and smaller structures, to progressively more complex systems, invisible to the naked eye, but central to what we understand as life. There was, in this movement, a clear logic: the deeper the look, the greater the possibility of understanding. However, it was precisely when I got closer to this microscopic universe that something unexpected happened. I was led to leave. This movement was not abrupt. There was no rupture, no founding crisis. Just like Ulysses in his crossing, the exit imposed itself almost as a natural unfolding of the path itself. From the micro, I was led to the macro not out of abandonment, but out of necessity. It is from this experience that I propose this reflection, inspired by the work *It is proper to the human*, by Dante Gallian, which describes human movement as a constant coming and going between interiority and exteriority. Entry, exit and return: three gestures that, more than stages, constitute the very condition of being. In my case, the realization that biology would not account for the totality of the human was not devastating. There was no disenchantment, there was recognition. As if, from the beginning, something already knew that this would not be the only way. So I did what I learned to do as a scientist: I looked for what was missing. And it was in this gesture that I found the humanities. The approach, however, was not only due to intellectual curiosity, it also emerged from a discomfort. All around me, I noticed signs of exhaustion: exhausted colleagues, unmotivated teachers, trajectories marked by a fatigue that seemed to exceed the limit of the physical. There was something that could not be explained only by the data, the techniques or the institutional requirements.

Gallian offers us a powerful image to think about this state:

Just as the constriction of a growing organism can lead to its death (imagine a fetus that refused to leave the mother's womb), the closure or limitation of the soul also ends up compromising its vitality, its health. The soul wants to go out, it needs space, and everything that hinders its growth dwarfs it; and a small soul is a sick soul. (p.37)

This idea echoed in me strongly. I began to recognize, in the academic experience, subtle forms of enclosure. Not because of a lack of intelligence or sensitivity, but because of structural constraints that limit movement. It is often said that it is necessary to expand, that there is life beyond the university, however, little is taught about how to carry out this displacement. And, if

it were indeed an accessible path, perhaps we would not witness so many processes of illness within the academy itself. It is not a question of incapacity. Many see, understand, intuit the need to go out. But there is a lack of conditions: material, institutional and, above all, training. The very logic of scientific production contributes to this. The scarcity of resources and the constant pressure for productivity create an environment in which staying in the already established becomes not only easier, but safer.

When I began my movement toward the humanities, I heard over and over again that I had chosen the simplest path. As if reflecting were less demanding than executing; as if thinking were a spontaneous and uncompromising exercise. But there is something profoundly wrong in this perception: having your own idea is perhaps one of the most difficult tasks that exists. In science, we are trained to answer questions; rarely to formulate them. We learn to look for references, to support arguments, to validate hypotheses. All of this is fundamental. However, the origin of science: astonishment, questioning, restlessness is gradually being silenced. It was in this context that I sought, during my doctorate, a discipline focused on poetic writing, offered by the Center for History and Philosophy (CeHFi) at UNIFESP. Initially, I just wanted a breather. A space that, even if accounted for in credits, would give me back some kind of pleasure. What I found, however, was a deeper displacement. I realized that my writing had become automatic. In healthcare, the production of articles is often structured as a repeatable model: efficient but predictable. Over time, one writes without thinking about the act of writing. And, in this process, something is lost.

Writing ceases to be creation and becomes execution.

The contact with poetry produced a strangeness in me. For the first time, it was not enough to know how to do it. It was necessary to have something to say and I didn't. This observation was, at the same time, disconcerting and revealing. I, who considered myself creative within science, could not produce an idea outside its molds. It depended on directions, themes, external stimuli. What I thought was creativity was, to a large extent, a response. In sharing this experience, I encountered predictable reactions: the discipline was seen as easy, almost irrelevant. His interest in the humanities aroused strangeness, sometimes even distrust. But, over time, I realized that this was not an objective evaluation of difficulty. It was the discomfort in the face of the displacement. Going out is uncomfortable. It bothers those who leave, but also those who remain. Because the movement of the other can be perceived as an invitation and we are not always willing to accept it. This tension is accurately expressed in "The Tale of the Unknown Island", by José Saramago. In it, the desire to leave comes up against

fear, self-indulgence and the absence of means. The crossing is not impeded by impossibility, but by resistance.

In science, this scenario is repeated.

Many feel the impulse to go further, to seek new ways of thinking, to integrate knowledge. However, few actually carry out this movement. Not for lack of desire, but for the costs it implies: more work, more uncertainty, more need for justification. Thus, contemporary science tends to focus on technical improvement. We refine methods, speed up processes, optimize results. This advance is undeniably important. But it is accompanied by a silent impoverishment: the reduction of the ability to formulate new questions. We are becoming experts in answers, but less and less accustomed to questioning. This distancing is not only epistemological; it is also social. By moving away from people's concrete experiences, we become less able to dialogue with them. And when this dialogue breaks down, there is room for mistrust. It is not surprising, therefore, that movements to question science are gaining strength. They arise not only from ignorance, but also from the absence of bonding. In view of this, a recurrent discourse emerges: the need to humanize science. However, this humanization often remains on the surface. It is recognized that there is a subject behind the object of study, but it is not deepened what this means. There is a lack of density, a lack of training, a lack of experience. In healthcare, we are highly qualified to understand the body, but when we go beyond this dimension, our tools become limited. Even the most expanded approaches rarely escape a logic that is still centered on the biological. And here lies a fundamental contradiction: in order to humanize science, it is necessary to allow the scientist to leave the "pedestal" and find experience based on reality. But the way of doing science does not favor and has never favored this possibility.

On the contrary, it requires continuous productivity, absolute neutrality and the erasure of subjectivity. Living, the experience, the singular look, everything that could enrich the construction of knowledge, is often delegitimized; If, on the one hand, science has theoretical knowledge of phenomena, practice in its entirety only occurs when there is a union of theoretical knowledge, technique and experience in the real world, since no protocol contemplates the subjectivity of life. In this process, the movement to leave is abandoned. However, this movement, this need to go out, although it may be ignored for some time, does not remain forgotten indefinitely. At some point, something erupts, something displaces, tenses, pushes; Whether on the individual or collective level, the impulse returns. Human beings can resist, science can postpone, but the way out, sooner or later, is imposed. And perhaps what we are witnessing today is precisely one of these impositions. The growth of anti-science movements does not arise in a vacuum. It is, in part, the consequence of a prolonged estrangement; We

have distanced ourselves from society, and now we see this distancing reverberating back, putting at risk the very sustainability of scientific activity. Because science does not exist without society. And that's something that, for a long time, we allow ourselves to forget. Even in its most technical view, in the biological and health sciences, there is an implicit direction towards human well-being. Even if we study animals, cells or abstract systems, ultimately, the question returns: what does this mean for the human being? We produce knowledge, to a large extent, focused on ourselves. There is, in this gesture, a certain "structural selfishness", not necessarily negative, but rarely problematized and, even so, paradoxically, we distance ourselves from people. It is in the encounter with the world, with the other and with the unknown that we recognize ourselves. Not just in thought, but in action. Not only in theory, but in experience. And, in the case of science, this experience requires concrete displacement, it is not enough to produce knowledge within the limits of the laboratory, it is necessary to cross these borders. Stepping into the real world, entering social spaces, living with those who are outside the academy. Because it is in this encounter that knowledge gains meaning.

Within the university, the logic of scientific production is already known. A graduate student knows what he needs to do to become a researcher. He masters the codes, understands the paths, recognizes the rules. The problem is not in the absence of knowledge, but in its circulation, knowledge remains retained. We produce a lot, but little of it crosses institutional walls, little reaches society, little seems to directly impact the lives of those outside this circuit, since few are capable of understanding scientific articles, which can lead to questioning their validity; What is the use of work that can only be understood by scientists? And, in view of this, a predictable perception is built: that science is inaccessible, distant, ultimately irrelevant. People don't see what we do, and what you don't see easily becomes what doesn't exist. If scientific work is not presented in concrete form, if it is not translated into perceptible experiences, then it is not difficult to understand why, for many, it seems to have no value. In this sense, returning to a formulation dear to Gallian, the central question may no longer be or not to be. In science, it is about something more direct: to do or not to do. And here, doing is not reduced to the internal production of knowledge. Doing implies making visible, sharing, transforming. As long as we remain restricted, formulating questions and answering them among ourselves, we will continue to be perceived as a closed circuit. And if no one sees what we do, the conclusion, even if mistaken, becomes understandable: that we do nothing. And from there, the leap is short: that science is useless.

2 ONE DOES NOT RETURN FROM WHERE ONE HAS NEVER LEFT: SCIENCE AND THE IMPASSE OF RETURN

If you're a scientist, you probably recognize the scenario I've been describing. Unless you inhabit a space where knowledge itself is taken for granted, it is not difficult to perceive that something is in tension. We live in a moment in which discourses about humanization, about appropriate language, about more sensitive practices are multiplying. Advisors remember the past, emphasizing how much worse it used to be, as if the simple comparison with harder times was enough to validate the present. And, in fact, it cannot be denied: there have been changes. Over time, part of the scientific community began to recognize flaws in the way science was done. And, within the possibilities they had, many researchers tried to transform their immediate spaces; creating more welcoming environments, less violent relationships, more conscious practices. I do not assume that scientists are, in essence, cruel. I prefer to understand this process as historical. Science itself, at different times, has been stressed to review its limits.

An important milestone in this movement is the Nuremberg Code, which establishes fundamental principles for research involving human beings, such as:

- The voluntary consent of the human being is absolutely essential
- The experiment must be such as to produce results advantageous to society, which cannot be sought by other methods of study, but cannot be done on a case-by-case basis or unnecessarily
- Special care should be taken to protect the experiment participant from any possibility of harm, disability, or death, even remotely.
- The experiment participant should be free to withdraw during the course of the experiment.

These principles were, and continue to be, essential, they represent a civilizational achievement. They delimit an ethical minimum necessary for research not to reproduce historical violence, but it is precisely here that a crucial point arises: this minimum is not enough. Comply with protocols, obtain approval from ethics committees, follow institutional regulations; All this ensures that abuses are not committed, but it does not guarantee, by itself, that science is, in fact, humanizing. If that were enough, we would not be facing so much criticism today. What is observed, in practice, is that many health professionals understand this set of rules as the humanization movement itself, as if, by complying with ethical requirements, the exit had already been carried out, but it was not. What happened was, in many cases, a premature return, a return to the interior of the area itself, with the feeling of accomplishment, it is at this point that criticism needs to be made, not to deny the advances, but to highlight their limits.

To make more concrete what I argue when I say that a set of norms is not, by itself, sufficient, I use an example. I argue that such regulations are fundamental to guarantee basic rights, which already represents a significant advance in the history of science. However, this does not necessarily equate to the production of a science that is truly committed to society. In this sense, the case presented in the documentary *Three Identical Strangers* is illustrative. The work portrays the true story of triplets who were separated at birth and sent to different adoptive families, without their parents knowing of each other's existence. Throughout the narrative, the siblings discover that they were part of a scientific study conducted without consent, whose objective was to investigate the impact of environmental conditions, especially different socioeconomic contexts, on the development of individuals with a family history of mental disorders.

The study, which involved several children in addition to the three siblings, consisted of separating biological siblings and inserting them into families with different social profiles, in order to compare their developmental trajectories. When the case came to light, it became a scandal, highlighting serious ethical flaws. A particularly significant aspect is the absence of clear accountability on the part of the researchers involved, who often justified their actions based on the context of the time or the lack of stricter regulations. This example clearly shows why the institutionalization of ethical norms is indispensable. However, it also allows us to advance the reflection I propose: the mere existence of protocols and their formal observance do not guarantee, by themselves, an ethical scientific practice in the full sense. What is at stake is not the need for norms, which is undeniable, but the contemporary tendency to reduce ethics to bureaucratic compliance with guidelines, as if this were enough to ensure the humanizing character of science.

It is precisely this reduction that needs to be problematized. Ethics, in this context, cannot be understood only as normative conformity, but as a broader commitment to the subjects involved and to the human implications in the production of knowledge.

[...] the success of humanization initiatives is intrinsically linked to the ability to integrate technical and socio-emotional skills, with alterity as a central element of this transformation (Dias, L., p. 5857).

The issue that arises, and with which I agree, is that it is not possible to restrict ethics to the observance of previously established technical protocols. These protocols are fundamental as guidance instruments, as they delimit, in a more controlled way, what can or cannot be done in the scope of the research. However, the definition of what effectively constitutes a humanizing

practice is not limited to compliance with these guidelines. In other words, although ethical protocols are necessary, they are not enough, ethics cannot be reduced to a technical procedure or a normative *checklist*. It is necessary to recognize that there is a dimension that escapes formalization, requiring sensitivity, critical reflection and responsibility towards the subjects involved. Thus, the challenge is not only to follow norms, but to sustain an ethical-humanist commitment that goes beyond them.

In view of this, an inevitable question arises: what to do, then?

The proposal I bring does not come in the form of an absolutist rhetoric, but comes from a reflection, when it comes to the health area, based on biological knowledge and ethical protocols are not enough to guarantee a so-called "humanizing" practice, because they exclude what makes human beings, humans, subjectivity, it would then be necessary to bring the practice and reflection on it. Knowing that the end if a person is death is totally different from witnessing it, lacks the dimension of reflective practical experience aimed at understanding subjectivity. And, for this, literature presents itself as a privileged path; as Dante Gallian states:

Literature, therefore, is not only art, but, precisely because it is art, it is also a form of knowledge. (p.75)

This idea was subsidized by Gregorio Marañón, a physician and scientist, who debated a greater possibility of learning about human love through reading Shakespeare than in philosophical treatises or biological writings. To illustrate this perspective, I turn to the poem "*Education through Poem II*", by Gisele Wolkoff, whose composition offers a sensitive way of approaching the idea developed here.

Postpone the verb in the name of time: Tie the threads of discord in a single knot of forgetfulness; to bind the sweet grains and unique flour of encounter and tenderness, to sew the threads of the famous mesh of sitaxis, even if in rupture, to thicken the wheat chaff with mild rye and postpone the departure: the vowel emotioned, the reticent interjection to transform the ellipsis into light exclamations of euphoria and to integrate the soft body of the entire field

At first glance, this statement may cause strangeness or even rejection. The initial feeling may be one of discomfort: what do you mean literature would occupy this place? Literature does not require, in its most basic access, specialized training. It is available, open, accessible. And, precisely for this reason, it can work as a gateway, a first displacement. An exit movement that does not impose itself as a rupture, but as an approximation. In my own training, I had contact with a proposal that illustrates this path well. In disciplines such as bioethics and biophilosophy,

the approach was not exclusively based on concepts, but also through literature. The starting point was, perhaps unexpectedly, Mary Shelley's *Frankenstein*. I say unexpected because, when I started my search for an undergraduate course, I never imagined that there would be room to learn through literature. For me, reading occupied other places: it was, above all, a form of entertainment or, at certain times, a requirement linked to the entrance exam. At that stage, still with an immature view, I could not conceive that literature could also be a relevant source of reflection and knowledge applied to the health area.

For a semester, we read him not as literary critics, but as students in the health field. The objective was not to analyze the work itself, but to use it as a tool to think about scientific practice. There, in the face of the narrative, we were confronted with issues that hardly emerged only through protocols or articles: responsibility, reflection, and ethics beyond what is described in the norms. Literature, in this context, does not replace scientific knowledge, but expands it. It introduces layers of meaning that escape purely technical logic, although it is recognized, in theory, that the human being is not limited to his biological dimension, in practice there is often a lack of integration on the part of the scientist himself. Like Victor Frankenstein, the researcher may find himself taken by the impulse of curiosity and a certain duty to do, without fully reflecting on the consequences of his actions. And here I sympathize with a character who has a beginning so close to mine:

The natural sciences were the compass of my life [...] I opened the book with apathy. But as I went deeper into the reading, the theory he tried to demonstrate and the wonderful facts he related ended up transforming that feeling into enthusiasm. A new light seemed to dawn in my mind (Shelley, M., p.38).

And here is the expression of a more primitive desire: I believe that no one chooses science without at some point having been deeply fascinated by it. One does not follow this path without something, at some point, having touched and impressed in a remarkable way. And the more one reads, understands and discovers, the more this impulse intensifies, continuously feeding a primordial desire to go further, to always seek more.

Sir Isaac Newton is said to have once confessed that he felt like a child picking up shells on the shores of the great and uncharted ocean of truth. (Shelley, M., p.40)

So far, while reading, I could only think about how deeply I understood Victor in his essence. In this first chapter, his impulses were entirely clear to me, almost as if I saw in him a mirror of myself. However, as I read it, I began to realize how these impulses, which arose from

such a legitimate and pure place, a place I recognized, were gradually transformed. Little by little, in the midst of arrogance and lack of direction, that young scientist ended up getting lost.

[..] having as an ally only the unbridled thirst for knowledge. Under the direction of my new masters, I threw myself, nothing more, nothing less, into the discovery of the philosopher's stone and the elixir of long life. Between the two, this last objective prevailed. Wealth was a secondary purpose, but what glory would be crowned by the discovery that would allow the banishing of disease from the human organism, making man invulnerable to all deaths, except that caused by violence! (Shelley, M., p. 40)

I remember that, at first, it was very difficult for me to understand at what point Victor "distorted" himself, when he lost this luster for science and at what point his thirst for knowledge transformed him into something that no longer seemed properly human. When, after all, did that scientist so promising meet his doom? Now, rereading and reflecting on this letter, on this outburst, I begin to realize that the deviation was perhaps present from the beginning. When considering the passage mentioned, in which he expresses the desire to discover the Philosopher's Stone and the elixir of long life, it becomes evident that he lacked basic foundations of scientific practice. There was an impulse to do for the sake of doing, sustained by an unshakable conviction that he was right. This ties in with something we discussed earlier: we learned that, to some extent, all knowledge needs to return to our own plane. We are so self-centered that knowledge needs to be appropriated, transformed, and somehow serve our interests as a species, not necessarily starting from a point that questions the impact of our actions.

It may seem easy to judge Victor precisely because his experiment sounds extreme: to create a complete and perfect human being. However, this distance may be illusory. To some extent, are we not, in our drive to heal or save humanity, trying to accomplish something similar, albeit on a smaller scale? The understanding that there is a subtle threshold that differentiates the understanding of phenomena, the construction of methods that aim to bring quality of life and the impulse to eliminate morphological imperfections; Doesn't the search to correct, improve and, ultimately, get closer to an ideal of perfection echo, in a way, the same movement? It is at this point that literature becomes truly formative: by confronting us with these questions, it expands our capacity for critical reflection and invites us to rethink the meaning and limits of scientific practice. The Arts attend to emotions and make room for the reinvention of the human, whenever it is uselessly necessary...

The Humanities have long claimed space in health education. And this claim seems to compete with the truth of the demands. But perhaps it is necessary to rethink the ways of

approaching. I speak here not as a researcher in the Human Sciences, but as a biomedical doctor. As someone who crossed, even partially, this outgoing movement, and who could perceive, in practice, the impact of this crossing. Literature is not a magic solution, nor is it a single path. But it opens up a field where we so often close ourselves, opening is, in itself, a radical gesture. It is necessary to understand this process not as the creation of a "hierarchy" where only one of the "sides" presents definitive answers, but to understand that the combination of knowledge opens up the possibility of admiring the subjectivity of the concept of "doing health" from different perspectives.

3 BETWEEN RUPTURES AND CONTINUITIES: REVISITING MODERN REASON

When reflecting on this movement that presents itself as a radical way out towards the humanities, my starting point was precisely philosophy, in dialogue with literature. At this initial moment, a decisive question arose: is this gesture of rupture, which today seems so innovative, in fact something new? Or are we just going back to previous ways of producing knowledge? This question displaces the problem and invites us to look historically at the ways in which science and knowledge have been constructed over time. It is in this sense that I turn to the work *The History of Western Civilization, as a way of situating this debate. Before directly addressing Descartes' so-called error, it seems essential to understand the logic that guided his thinking and the reverberations that still structure our way of understanding the world today.*

René Descartes has consolidated himself as one of the main exponents of modern rationalism, although he was not the first to value reason as a way of access to knowledge, his proposal is distinguished by a systematic refusal of authority and tradition as criteria of truth; in opposition to the medieval Scholastics, Descartes proposed a method based on doubt and deductive construction, inspired by mathematics. Their procedure consisted in starting from principles considered self-evident and, from them, deducing particular conclusions. In this context, the famous principle "I think, therefore I am" emerges, conceived as an undoubted foundation of knowledge. From this base, Descartes believed it was possible to build a coherent and universal system, capable of demonstrating, for example, the existence of God and the distinction between mind and body. In addition to rationalism, his contribution also involves the formulation of a mechanistic view of the universe. From this perspective, all natural phenomena could be explained in terms of matter in motion, governed by universal laws; The world, organic and inorganic, came to be understood as a great mechanism. Even so, Descartes maintained a fundamental dualism: while the body belongs to the material order, thought constitutes a distinct substance, not reducible to matter.

After Descartes, different thinkers dialogued with his ideas, whether they deepened them or criticized them. This path leads us to the Enlightenment, which represents a decisive moment in the history of Western thought. Emerging in England at the end of the seventeenth century and widely spread throughout Europe, especially in France throughout the eighteenth century, the Enlightenment consolidated the centrality of reason as a criterion of truth.

Reason is the only infallible guide to wisdom. All knowledge has its roots in sensory perception, but the impressions of our senses are nothing more than the raw material of truth, which needs to be purified in the crucible of reason before we can use it to explain the world or to indicate the way to a better life (Burns, E., 1968, p.549).

At this point, I make a brief, more personal inflection. The writing of this text did not follow a linear path, but was configured as a movement of comings and goings. I started from the proposed reflections, I incorporated new readings and theoretical references. Although it is a letter, and not a scientific article, it has become necessary to build a consistent argumentative ballast. In this process, the reading of works caused important shifts in my understanding. The experience was, in many ways, similar to a crossing: a journey that required revisiting knowledge that was apparently already consolidated. When I returned to the Enlightenment, for example, I had the initial feeling of being in front of something new, when, in reality, it was a content that had already been studied. This perception highlighted not only gaps in my training, but also the effects of an educational model that often hierarchizes knowledge. During my school career, the disciplines of the exact sciences received greater attention, in part because of the difficulties they imposed on me, while the humanities were, albeit involuntarily, relegated to the background. Therefore, to take up these ideas relegated to the scope of this less brief epistolary reflection is like collecting all the instruments of navigation and gathering them in front of me, before embarking on deep seas...

Resuming the thread of argument, it is important to highlight that the Enlightenment was deeply influenced by both rationalism and the scientific advances of the time. In this context, Isaac Newton played a central role in formulating laws capable of mathematically describing the workings of nature. His theory of universal gravitation exemplifies the idea that the universe is governed by invariable principles that can be precisely formalized. Alongside Newton, John Locke contributed to the valorization of experience as a source of knowledge, articulating it with rational activity. The result of this set of transformations was the consolidation of a worldview in which natural phenomena came to be understood as governed by universal laws, moving away from teleological interpretations typical of medieval thought. The universe is no longer

conceived as oriented by intrinsic purposes and is now described as a system regulated by causal relations, comparable to the precise functioning of a machine.

4 MIND AND BRAIN IN SCIENCE: BETWEEN REDUCTIONISM AND LOSS OF MEANING

And it is at this point that we finally reach the core of this reflection. Throughout this letter, I insistently return to the tension between fragmentation and integration in the production of scientific knowledge, as well as mechanistic knowledge. And not by chance: those who work in the area know how challenging it is to sustain, in practice, a truly interdisciplinary movement. Integrating knowledge is not only a theoretical guideline, but a concrete, everyday difficulty. In recent years, this challenge has been explicitly recognized in the Brazilian context. Law No. 13,005/2014 inaugurates an important movement by proposing greater articulation between university and society, later consolidated by guidelines that, as of December 18, 2018, with Resolution CNE/CES No. 7, sought to make this integration effective. Having joined the university in 2020, I followed the beginning of this process and witnessed up close the effort of professors to build new methodologies that would take knowledge beyond institutional walls. This movement, already complex in itself, was further strained by the context of the pandemic, which made its implementation especially challenging. Given this, an inevitable question began to impose itself: have we always done science in this way? Is this fragmentation an intrinsic and immutable characteristic of scientific knowledge? A reading of *Descartes' Error* by scientist Antonio Damasio suggests not.

It is at this moment that the figure of Descartes comes in, not only as an author, but as a symbol of a set of ideas that profoundly shaped Western thought. His dualistic proposal, which separates mind and body into distinct substances, had a lasting impact on both the sciences and the humanities. The famous formulation "I think, therefore I am", presented in *Discourse on Method* (1937), crystallizes this separation by suggesting that thought constitutes the foundation of existence. However, the criticism proposed by Antônio Damásio points to a central problem: this inversion ignores the fact that, from the biological and evolutionary point of view, existence precedes thought. Before thinking, organisms exist; Before complex consciousness, there are more elementary forms of life regulation. In this sense, thought is not the origin, but the consequence of a living, structured and functional organism. The so-called Descartes error, therefore, is not reduced to specific misunderstandings about the functioning of the body, many of which have already been overcome, but concerns a deeper and more persistent separation: the dissociation between mind and body. This division supports the idea that processes such as reasoning, moral judgment, or emotional experience could be understood independently of

the biological organism that makes them possible. The consequences of this perspective are wide-ranging. In medicine, for example, she has contributed to an approach that often dissociates body and mind, treating biological and psychological aspects as separate domains. In the cognitive sciences, it manifests itself in the idea that the mind could be understood as a software, relatively independent of the brain hardware, a metaphor that, although useful in certain contexts, reveals limitations when confronted with the complexity of the living organism. Damasio does not deny the centrality of the brain in mental processes, on the contrary, he recognizes that thought emerges from brain activity. However, he argues that this formulation is insufficient if it disregards the body and the environment in which this brain is inserted. The organism is not only a support, but an active condition of the mind. Body, brain, and world form an integrated and dynamic system.

In this sense, the criticism is directed not only at classical dualism, but also at its more subtle contemporary versions, which maintain, albeit implicitly, the separation between mind and body. The problem is not in recognizing analytical distinctions, but in absolutizing them to the point of losing sight of the articulation between the parts. Perhaps the current movement of science can be understood precisely as an attempt to revise this legacy. If, at a certain moment, it was necessary to separate in order to know, today we are faced with the opposite challenge: to integrate in order to understand, and this integration is still under construction, there is no finished model, nor definitive answers. What we can say, with some certainty, is that strict separation has not been enough and recognizing this does not mean abandoning the path taken, but understanding it as part of a broader process. Fragmentation was, and remains, a fundamental strategy, but it is not enough on its own. Thus, what I propose is not to solve the mind-brain dilemma, nor to exhaust its implications. It is, rather, to situate it historically and use it as a starting point for a broader reflection: that understanding the human being inevitably requires the effort to articulate what, for a long time, we have learned to separate.

5 REFLECTING AND DISCERNING: WHAT IS PROPER TO THE HUMAN AND FOUNDS SCIENCE

There is something curious and, why not, disturbing at the moment when we realize that terms such as reflection and discernment are no longer immediately associated with scientific practice, especially in the health sciences. I remember a conversation with a colleague, to whom I explained the procedures of statistical analysis of my work, developed from the methodology of thematic oral history. As I described the process, he interrupted me, surprised: Wow, I thought it was just philosophizing. The only thing that did not go unnoticed.

Since when did reflecting become synonymous with something smaller? At what point was reflection reduced to an expendable, almost ornamental exercise in the face of what is conventionally called the science of truth? In the biomedical sciences, we are used to valuing what is statistically significant. We transform biological data into numbers, submit them to statistical tests and, from them, build interpretations. There are questions that only the number answers, but there are others that only reveal themselves to those who are capable of reflecting. And reflecting, here, is not an automatic gesture. It requires method, yes, but it also requires sensitivity, listening and the ability to sustain the complexity of what the other presents to us. Above all, it requires the courage to connect what, at first sight, seems irreconcilable: the biological datum and the lived experience. And how could this seem simple?

It is at this moment that I turn once again to literature, this space where the human experience reveals itself in its deepest density. In *Grande Sertão: Veredas*, João Guimarães Rosa presents us with a fundamental concern: the search for a path that, although it exists, does not show itself in an evident way. Each person, the work suggests, carries with them a kind of script of existence, a possible direction, even if hidden. And to live would be, in some way, to try to find it. If we take this image as a starting point, it becomes difficult to sustain a health science that does not understand, at least, what a person is.

How can we talk about health without considering the complexity of those who live there?

Before any protocol, before any method, there is a previous and unavoidable question: what constitutes a human being? Without this understanding, any attempt to produce knowledge about health runs the risk of becoming incomplete, if not mistaken. In this sense, achieving what we could call a fair measure requires breaking with the mediocrity of automatism, which arises as a result of an education based on following technological trends in an impractical way.

In recent decades, the increase in the production and incorporation of new technologies has been associated with improved prevention, diagnosis, and treatment of diseases, which has had an impact on an increase in quality of life and a decrease in mortality in general. However, this situation has generated a considerable increase in costs in the health sector [...] Among the possible explanations for this phenomenon, the fact that new health technologies are more expensive and have a cumulative aspect is justified, unlike other sectors where the inclusion of a new technology tends to replace previous ones (AMORIM, F., 2011, p. 344)

Here it is not a matter of denying that these technological advances do not bring any benefit, but of understanding that we are very focused on the uncontrolled production of new techniques/technologies, but that we often do not think about their real application in the clinical

or even scientific context, demonstrating a clear absence of a deep reflection on doing in science. It is for this reason that this context requires abandoning the security of ready-made recipes and opening up to experience, not as an uncontrolled error, but as a legitimate space for learning. Science does need technical rigor, method, theoretical foundation. Without this, it dissolves into opinion, but there is something equally indispensable: the awareness that the knowledge produced is only a part of a greater whole. When we recognize that biology does not offer all the answers, we make room to reintegrate into science what should never have been excluded: experience. And, in a way, we already do this, albeit silently. When a protocol indicates the use of a certain amount of a reagent, but laboratory practice teaches us that it is possible to adapt it, we are, in fact, operating from experience. The question, then, is not to introduce experience into science, it is already there. The point is to recognize that it must also inhabit the way we think, interpret and question our objects of study.

In this path, reflection arises as a response to a kind of revelation: that a health science restricted to the biological is not enough to produce care, neither ethics nor humanity. And, once crossed by this perception, we are summoned to another movement: that of discernment. To discern is to judge, distinguish, evaluate; it is to recognize the origin and quality of what crosses us, whether data, theories or discourses. In times marked by the overvaluation of a narrow rationalism and, paradoxically, by the growing inability to think critically, this skill becomes even more urgent. We live surrounded by ready-made speeches, simplified interpretations, and an avalanche of information that requires, more than ever, the ability to separate what is consistent from what is just convincing. In the scientific field, this becomes particularly delicate; The authority of scientific discourse is often used to legitimize superficial, sensationalist or even mistaken statements. And so, little by little, we run the risk of becoming what we criticize the most: subjects who accept without question.

The excessive protocolization of science is one of the symptoms of this process. How can a health scientist claim to understand the human being and reduce his definition to the biological dimension? How can you accept a protocol without questioning its limitations? There is an evident contradiction here: while we denounce the uncritical adherence to the so-called fake news, we reproduce, to a certain extent, a similar logic when we stop questioning what is presented to us under the seal of science. The difference is that, in this case, the risk is even greater, because it is accompanied by the legitimacy of scientific discourse. Perhaps the central point is this: it is not possible to understand the complexity of a human being from a single axis. No protocol, no matter how sophisticated, is capable of encompassing the totality of human experience, and recognizing this does not weaken science, on the contrary, it strengthens it.

Because it is precisely in this space of tension, between what we know and what still eludes us, that science becomes, in fact, human.

And here, reader, I need to tell you: on this point, perhaps you disagree with me. Perhaps he has come this far moved by the desire to refute each of these ideas, to organize, in his own angle, an answer. Or, perhaps, some of what was said had, however uncomfortably, found resonance in you. Be that as it may, there is something that cannot be ignored. It's easier to stay. It is easier to produce work that fits the expected pattern. It is easier to sustain a line of research that is already legitimate, to obtain funding, to be recognized by peers, to have one's own work promptly classified as useful. There is comfort in this place and there is also reward, but that is precisely where the risk lies.

I evoke here Fernando Pessoa, in his poem *The Fifth Empire*: Sad for those who live at home, content with their home. Because doing science, in its deepest dimension, requires courage. To get out of the comfort zone, to get out of ready-made answers, to get out of structures that, although safe, also limit. No line of research can be sustained intact forever. One can even keep the same object of investigation, but the way of approaching it will inevitably need to be transformed. Science that does not move, stagnates. You may disagree with me when I say that the humanities are a path to a more structured science. This disagreement is legitimate and, in a way, necessary. But there is one point that remains unavoidable: it is not possible to do science without breaking, to some extent, with self-indulgence. Because it is in displacement, and only in displacement, that something truly new can emerge.

6 THE SCIENTIST'S ODYSSEY: BETWEEN LITERATURE AND SCIENTIFIC PRACTICE

It is possible that, at this point, reader, you have the impression that, by criticizing the structures of science as they are, I not only expose their weaknesses, but also make even more arduous a trajectory that is already proving to be exhausting in itself. And in this regard, I must be honest with you: yes, it is difficult. I say not from a distant place, but from the interior of the crossing itself. I walk through it now, as do I dare suppose many of those who read me. Entering academic life, aspiring to a place in it, building oneself as a professor or researcher: all this already carries a considerable weight in itself. And it is no secret how much this path has sickened those who follow it. For us, who still seek to enter this space, the landscape is sometimes even more arid. To the competition and suffering are added the urgencies of the concrete world: financial limitations, external pressures, the life that insists on happening beyond the walls of academia. None of this can be ignored.

I do not write, however, to condemn or prescribe immediate changes, as if it were enough to name the problems for them to be solved. I only hope that I have made it clear that any transformation, whether in the way of producing science or in the way of inhabiting it, is far from simple. I speak of what I know: of what I live. There is, indeed, a devaluation of science, and it is felt even more acutely when one chooses to walk through the Humanities. It was, perhaps, for this reason that I found a certain encouragement in literature.

When I pored over *The Odyssey*, especially in more attentive readings, I realized something that goes beyond the practical demands of life, even if these are unavoidable. After all, it is necessary to live: to pay rent, to feed oneself, to support oneself. Science, however lofty, does not exempt us from these needs. And yet, between one page and another, a concern emerged: was I, like so many others, not looking for a safer, more direct, more predictable path than academic life itself allows? Wouldn't I want a trajectory that offered guarantees? But the truth, little by little, imposed itself: there is no path that promises this. I remember a passage that crossed me:

Would Ulysses have been the Ulysses of the Odyssey if his return to Ithaca had occurred like that of the other heroes of the Iliad, without so many setbacks, adventures and sufferings? If that were the case, his story would not deserve a poem of his own. (Gallian, D., p.168)

I do not bring this passage to glorify suffering, but it has led me to an uncomfortable and, at the same time, profoundly human understanding: pain, error, deviation, everything we have learned to avoid, also constitutes us. We live under the ideal of an existence without pain, without loss, without death. Science itself, in many of its efforts, is guided by this horizon: to cure, to prolong, to preserve. And this is undoubtedly necessary. But there is a silent paradox, because in trying to eliminate everything that hurts us, wouldn't we also be trying to erase part of what makes us human? As someone trained in biomedical sciences, I cannot ignore this desire to overcome limits, it also inhabits me. Still, I recognize: there are dimensions of experience that will not be eradicated. The biology of the human is not dissociated from pain; on the contrary, he walks with it. And, at this point, I allow myself a reflection that I do not extract from books, but from my own experience: Ulysses did not face his obstacles in search of glory. He did not sail rough seas wondering if his name would echo through the centuries. His desire was another, simple, intimate one: to return home, to meet his wife again, to see his son, to recover his place in the world. Perhaps therein lies a question that often escapes us: what, after all, are we fighting for?

In the academic environment, it is easy to confuse purpose with recognition. Publishing in a certain journal, entering a certain university, winning scholarships and titles, all this becomes a metric of value. But in the middle of this race, there is a risk of losing something essential: genuine curiosity, the true link with what is being investigated. What moves you? Was it prestige or interest that brought you here? Was it the opportunity or the discovery of meaning? There is a subtle but decisive difference between those who only transit through a theme and those who inhabit it. The latter speak with propriety because, at some point, they made that object their own. They did not arrive by chance; they arrived by choice or, at least, stayed by it. When the focus is fixed exclusively on the goal, on the path already traced, on what must be done, something is lost. Individuality is diluted, curiosity is weakened. One starts to produce not by desire, but by adequacy. And, yes, it's true: that's often exactly what the system requires.

I remember an advisor who, with remarkable lucidity, once said to me: it is possible to disagree with the system, but to transform it, it is first necessary to be inside it. Perhaps this is the task: to understand the space we occupy, to recognize its limitations and, even so, to find gaps, small but real, to sustain what moves us. No path is without pain. No choice completely spares us from suffering. What remains for us, then, is to choose what, despite everything, brings us closer to some meaning. If Ulysses had given up in the first adversity, his story would have ended there: silent, without memory. Each of us needs to decide, along the way, how far we are willing to go and why. If the choice is to remain, and it will not always be, let it be at least a conscious permanence. And, along the way, I allow myself a simple piece of advice: read.

Literature keeps what, little by little, we have forgotten. Works like *Frankenstein* or the *Odyssey* don't just narrate journeys, they return us to the axis, reminding us of what we are made of. Because if we forget that we are human, there will be no science, no knowledge, and no place we can truly inhabit. And so I close these lines: not as a conclusion, but as a record. A small fragment of my own odyssey.

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FACTORS RESTRICTING RURAL CREDIT FOR FAMILY FARMING FROM THE PERSPECTIVE OF CREDIT ANALYSTS AT THE SICOOB CENTRO COOPERATIVE

FATORES DE RESTRIÇÃO AO CRÉDITO RURAL DESTINADO À AGRICULTURA FAMILIAR NA PERSPECTIVA DOS ANALISTAS DE CRÉDITO DA COOPERATIVA SICOOB CENTRO

FACTORES QUE RESTRINGEN EL CRÉDITO RURAL PARA LA AGRICULTURA FAMILIAR DESDE LA PERSPECTIVA DE LOS ANALISTAS DE CRÉDITO DE LA COOPERATIVA SICOOB CENTRO



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ABSTRACT

Family farming is one of the most outstanding activities in Brazilian agribusiness. In addition to productive contributions, family producers, among other economic and social contributions, collaborate especially in income distribution and maintenance of men in the countryside. However, family farmers face challenges in developing their activities, such as the restriction on obtaining rural credit. With this, the present study sought to analyze the factors that restrict rural credit for family producers in the credit cooperative Sicoob Centro, in the city of Ji-Paraná in the state of Rondônia. In addition, the study also endeavored to analyze the profile of family producers who take out rural credit, survey the main lines of credit used by rural family producers and investigate with Sicoob Centro credit analysts the actions that can minimize credit restrictions. For that, descriptive research with a quantitative approach was used through the deductive method. As for data collection, bibliofigureical research, documentary research and field research were used, using a questionnaire with open questions, with 13 responses being collected from credit analysts at Sicoob Centro. As a result, it was noticed that the majority (14.52%) of family producers who take credit from the cooperative are aged between 44 and 48 years old; 67.16% of family farmers work in beef cattle; and 91% of the credits taken are in the PRONAF Costing and Pre-Costing modality. In addition, it was also found that, according to the interviewees, the main factors restricting rural credit for family farmers are the high indebtedness of producers, lack of information about the borrower, delay in granting credit and the lack of guarantees.

Keywords: Rural Credit Analysis. Rural Credit Lines. Pronaf.

RESUMO

A agricultura familiar é uma das atividades mais destacáveis no agronegócio brasileiro. Além das contribuições produtivas, os produtores familiares, dentre outras contribuições econômicas e sociais, colaboram especialmente na distribuição de renda e manutenção do

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homem no campo. No entanto, os agricultores familiares encontram desafios para desenvolver suas atividades, a exemplo da restrição na captação de crédito rural. Com isso, o presente estudo buscou analisar os fatores de restrição ao crédito rural destinado aos produtores familiares na cooperativa de crédito Sicoob Centro, na cidade de Ji-Paraná no estado de Rondônia. Além disso, o estudo também diligenciou analisar o perfil dos produtores familiares que contratam o crédito rural, levantar as principais linhas de créditos utilizadas pelos produtores familiares rurais e apurar junto aos analistas de crédito da Sicoob Centro as ações que podem minimizar a restrição ao crédito. Para tanto, utilizou-se a pesquisa descritiva com abordagem quantitativa por meio do método dedutivo. Quanto à coleta de dados utilizou-se a pesquisa bibliográfica, pesquisa documental e a pesquisa de campo, está com utilização de questionário com questões abertas, sendo coletadas 13 respostas dos analistas de crédito da Sicoob Centro. Como resultados, percebeu-se a maioria (14,52%) dos produtores familiares que tomam crédito na cooperativa possuem idade entre 44 a 48 anos; 67,16% dos produtores familiares atuam na bovinocultura de corte; e 91% dos créditos tomados são na modalidade PRONAF Custeio e Pré-Custeio. Ademais, também foi constatado que, de acordo com os entrevistados, os principais fatores de restrição ao crédito rural destinado aos agricultores familiares são o endividamento elevado dos produtores, falta de informações a respeito do tomador do crédito, demora nas concessões do crédito e a falta de garantias.

Palavras-chave: Análise de Crédito Rural. Linhas de Crédito Rural. Pronaf.

RESUMEN

La agricultura familiar es una de las actividades más destacadas del agronegocio brasileño. Más allá de sus contribuciones productivas, los agricultores familiares, entre otras contribuciones económicas y sociales, contribuyen especialmente a la distribución del ingreso y a la permanencia de la población en las zonas rurales. Sin embargo, enfrentan desafíos para desarrollar sus actividades, como las restricciones para acceder al crédito rural. Por lo tanto, este estudio buscó analizar los factores que limitan el acceso al crédito rural para los agricultores familiares en la cooperativa de crédito Sicoob Centro en la ciudad de Ji-Paraná, estado de Rondônia. Además, el estudio también tuvo como objetivo analizar el perfil de los agricultores familiares que contratan crédito rural, identificar las principales líneas de crédito utilizadas por los agricultores familiares rurales y determinar, a partir de la información proporcionada por los analistas de crédito de Sicoob Centro, las acciones que pueden minimizar las restricciones crediticias. Para ello, se empleó una investigación descriptiva con un enfoque cuantitativo mediante el método deductivo. En cuanto a la recolección de datos, se utilizó investigación bibliográfica, documental y de campo, empleando un cuestionario con preguntas abiertas, del cual se obtuvieron 13 respuestas de los analistas de crédito de Sicoob Centro. Los resultados mostraron que la mayoría (14,52%) de los agricultores familiares que solicitan préstamos a la cooperativa tienen entre 44 y 48 años; el 67,16% se dedica a la cría de ganado vacuno; y el 91% de los préstamos se otorgan bajo las modalidades de Costo y Precosto de PRONAF. Además, se constató que, según los entrevistados, los principales factores que limitan el acceso al crédito rural para los agricultores familiares son el alto endeudamiento de los productores, la falta de información sobre el prestatario, las demoras en la aprobación de los préstamos y la falta de garantías.

Palabras clave: Análisis de Crédito Rural. Líneas de Crédito Rural. Pronaf.

1 INTRODUCTION

Brazilian Agribusiness is one of the main sectors of the country's economy, having a large share in Brazil's Gross Domestic Product (GDP). In 2020, agribusiness had a share of 26.6% in the national GDP, according to data from the Confederation of Agriculture and Livestock of Brazil (CNA, 2021). As a consequence of the growth of agribusiness, there is, for example, a significant increase in job creation and income distribution in the rural context. According to data from the General Register of Jobs and Unemployed (CAGED), in the first half of 2021, 152,496 new formal jobs were generated in the sector.

Due to the great growth of Brazilian agribusiness, producers seek to invest in increasing production, as well as investing in better structures and equipment. Rural producers, when they need resources, either to invest or to fund their production, resort mainly to financial institutions, whether they are commercial banks or credit unions.

Currently, credit unions are receiving significant demand for credit, as they have the capacity to offer better conditions to their members, even subject to risks. For this reason, a careful analysis is necessary, which reduces the risks in granting credit. Rural credit collaborates with the development of the country's economy, influencing national development. Rural credit favors producers, making it possible to invest in their properties, invest in inputs or buy new machinery (JONAS *et al.*, 2015).

Thus, rural credit can be understood as economic resources that are offered by financial institutions following the rules of the National Rural Credit System (SNCR), as provided for in Law No. 4,829, of November 5, 1965. The SNCR guarantees the granting of rural credit with rates, grace periods and payments different from other credit lines offered by financial institutions. Rural credit is considered one of the most important mechanisms of the country's agricultural policy (BACHA *et al.*, 2005). For Ziger (2013), rural credit acts as a generator of new opportunities, as it encourages producers to obtain new technologies, provides improvement in structures and modernization of the rural area, strengthening the permanence of farmers in the activity.

In 1995, the Brazilian government, aiming to promote rural development, created the National Program for the Strengthening of Family Agriculture (PRONAF), which aims to serve family farmers in order to strengthen their developed activities. In 2021, the Brazilian government made R\$ 39.34 billion available for family farming in the 2021/2022 Crop Plan (VALENTE, 2021). For the 2022/2023 Crop Plan, R\$ 53.61 million were made available (VILELA, 2022). In the years 2020 and 2021, the credit cooperative Sicoob Centro made

available R\$ 111,998,305 for PRONAF credit, totaling more than 1,272 credit contracts, in its branches operating in the state of Rondônia².

Prior to the creation of the National Program for the Strengthening of Family Agriculture (PRONAF), rural credit was predominantly directed to large rural producers, but after its constitution there was an expansion of access and inclusion of family farmers in rural credit (SILVA, 2006). With the creation of PRONAF, family farmers had access to the services offered by the national financial system, so PRONAF has presented itself as a more effective alternative for Brazilian family production (MATTEI, 2015).

In certain situations, family producers are unable to have their own resources to subsidize their rural activity, and it is necessary to resort to financial institutions. With the implementation of PRONAF, it facilitated access for producers to rural credit, with the benefits of reduced rates and annual payment periodicity. In this way, family workers who work in rural areas obtain resources to maintain or expand their activities.

However, there is a possibility that the required credit may be denied when the producer requests the resource, as it is up to the institutions that grant PRONAF to evaluate the proposals according to their internal rules and resolutions. In addition, PRONAF credit is usually limited, and it is not possible to meet all the needs of small producers. Therefore, it is also common for financial institutions, such as credit unions, to have their own specific lines of credit for this audience. However, the own lines are also subject to prior analysis and restriction.

Thus, in view of the possibility of the required credits being denied by the financial institutions that operationalize the resources, the following problem needs to be clarified: *from the perspective of the credit analysts of the Sicoob Centro cooperative, what are the main factors restricting rural credit that family producers experience?*

Thus, this work aims to analyze from the perspective of credit analysts of the Sicoob Centro cooperative, what are the main factors of restriction to rural credit that family producers experience. With specific objectives, it is expected to analyze the profile of family producers who contract rural credit at Sicoob Centro, survey the main credit lines used by rural family producers at the Sicoob Centro Credit Cooperative and ascertain with Sicoob Centro's credit analysts the actions that can minimize the restriction on PRONAF credit.

It should be noted that this is all pertinent in view of the growth of agribusiness and its relevance to the country. Thus, rural producers tend to seek more investments and resources to maintain and expand their activities and meet market demands. According to the Center for

² The Sicoob Centro credit cooperative operates in the Rondônia municipalities of Ariquemes, Governador Jorge Teixeira, Jarú, Ji-Paraná, Machadinho do Oeste, Mirante da Serra, Ouro Preto do Oeste, Presidente Médici, Urupá and Theobrama.

Advanced Studies in Applied Economics (CEPEA, 2021), in partnership with the Confederation of Agriculture and Livestock of Brazil (CNA), in the first quarter of 2021 there was a 5.35% increase in GDP growth in the sector compared to 2020. This indicator demonstrates the strong growth of agribusiness in the national economy.

With the growth of agribusiness, family producers feel the need to take rural credit to maintain or invest in their activities, but these producers in some situations encounter difficulties when they need these resources, whether due to lack of information, lack of knowledge in the field, lack of knowledge in the use of the resource, among others. However, research on this topic is scarce, however, of great relevance, since it has a great impact on GDP, income distribution and the generation of direct and indirect jobs.

Thus, it is expected that the information from this research will contribute to other researchers as a source of content for future projects, as well as to the professionals who work in rural areas. In addition, the study of the granting of rural credit to family producers will also show the main credit lines used, the profile of these professionals and will provide the development of strategies for better access to resources, thus minimizing credit restriction events.

2 THEORETICAL FOUNDATION

2.1 CONTEXTUALIZATION OF BRAZILIAN AGRIBUSINESS

According to Arieira (2017), agribusiness can be understood as all economic activities that contribute, directly or indirectly, to the processes of production, industrialization and commercialization from agricultural products. Thus, agribusiness comprises from activities that produce or develop goods, products and services for the field to the final agricultural product, with a view to maximizing profit in the context of the agri-food system (VILELA; MACEDO, 2000). Similarly, Gasques *et al.* (2004, p. 8) state that:

Agribusiness is seen as the production chain that involves everything from the manufacture of inputs, through production in agricultural establishments and its own. Transformation, until its consumption. This chain incorporates all support services: research and technical assistance, processing, transportation, marketing, credit, export, port services, dealers, stock exchanges, industrialization and the final consumer. The added value of the agro-industrial complex necessarily passes through five markets: the supply market; that of production itself; processing; distribution; and that of the final consumer.

According to Taliarine and Ramos (2015), due to the increase in the world population, there is also a need to increase food production, as a consequence of this population increase,

it gradually reduces the arable areas in the world. In this way, Brazil is strengthened on the world stage as a major food supplier. In this way, agribusiness has great economic relevance for Brazil, moving millions of reais in resources, producing direct and indirect jobs.

Jank *et al.* (2005) state that national agribusiness has potential worldwide in the production of agricultural commodities, with the capacity to expand supply, union of factors of investments in technology and research, which allow a significant increase in productivity.

The increase in agricultural productivity in recent years is noticeable throughout the country. With the increase in population, there is a need to increase agricultural production, thus expanding the trade in the agricultural sector. Brazilian agribusiness has been growing, due to the competence of farmers, the availability of affordable cultivable soils, the generation and aggregation of new technologies that are more productive and efficient (PINTO, 2006).

According to Lourenço and Lima (2009), on the world stage, Brazil is seen as a world leader in agribusiness. Hamann *et al.* (2010) state that Brazilian agribusiness is stable in the (inter)national context, but the country has a deficit of managerial qualification of some professionals who work in the agricultural sectors, especially in family farming.

Brazil is currently the world's fourth largest exporter of agricultural goods, exporting an average of USD 100.7 billion, behind the European Union, the USA and China. With this, it is noted that agribusiness is extremely important for the economic development of the country. In 2020, agribusiness totaled R\$ 1.98 trillion, representing 27% of the Brazilian GDP, according to data from CNA (2021).

2.1.1 Family Farming

In Brazil, family farming is the main activity responsible for generating products for consumption. Law No. 11,326, of July 24, 2006, in summary, defines that the family producer is one who performs activities in rural areas, does not have an area larger than four fiscal modules and the management of the establishment and the labor of the activity is the family's own.

According to Souza (2019), family farming, despite being extremely necessary for the turnover of the local and national economy, still suffers enormous disadvantages compared to the employer economy. From there, through the family farming producers themselves, the need to form cooperatives and associations that strengthen their business arises, which has as its main objective to provide technical assistance and incentive policies for the movement of agribusiness. Therefore, some advantages may not only be available to large producers, but also to those who are responsible for generating income and developing the local economy.

As for the profile of producers, in the last census of the Brazilian Institute of Geography and Statistics (IBGE) carried out in 2017, of the total rural properties in Brazil (5,073,324 properties), about 76.8% represented family farming (3,897,408 properties), comprised in an area of 23% of the total land dedicated to the exploitation of agricultural activities in the country. In the same year, about 66.3% of the workers in agricultural activities referred to family farmers. In addition, approximately 81% of family farming producers were rural landowners. In a survey carried out by Oliveira (2016), the profile of family farmers 79% represented the male sex and 21% the female sex, and the age groups distributed 59% over 40 years old, 26% between 31 and 40 years old and 15% between 21 and 30 years old.

As for access to capital, family farmers have public subsidies to promote agricultural production. To have access to public policies to encourage production and income generation, family farmers need to issue the Declaration of Aptitude for the National Program for the Strengthening of Family Agriculture (DAP), which is a mechanism used to identify and qualify Family Units of Agrarian Production (UFPA). The DAP presents personal data of the landowners, productive data of the property, territorial data and family income. For family farmers to have access to PRONAF rural credit, for example, it is essential to present the DAP, as it presents relevant information that will give confidence to financing transactions (BRASIL, 2022).

2.2 GRANTING OF CREDIT

For Meirelles (2008), credit aims to provide resources for the development of business or investments by productive organizations. In addition, Lemes *et al.* (2002) define credit as an instrument to improve and contribute to the realization of investments in the branches of organizations. According to Castro Neto and Sérgio (2009, p. 21) "credit plays an important economic and social role, as it enables the circulation of wealth and meets the needs of economic agents".

Therefore, credit can be defined as the assignment of capital to third parties, the resource assigned through remuneration (interest) required from the debtor for its use, which can be made available to individuals and legal entities (CAMARGOS *et al.*, 2010).

Thus, the granting of credit consists of the provision of a present value, through a commitment to pay, similarly to the value, in the future. The debtor is obliged to make payments on the dates agreed upon at the time of negotiation. Credit risk is the risk of loss that occurs when the borrower is unable to pay in a credit granting operation. Therefore, institutions must

carry out credit assessments to mitigate losses in operations, which may or may not be detailed (FRANCISCO, 2007).

2.3 RURAL CREDIT AND CREDIT ANALYSIS

Rural credit is a financial resource offered by financial institutions aimed at the rural segment. Rural farmers benefit from the resources provided by financial organizations in this line of credit in numerous ways in their property and rural businesses. These credits have four main purposes: costing, investments, commercialization and industrialization, as described in table 1:

Table 1

Types and purposes of rural credit

TYPES OF CREDIT	PURPOSES OF RURAL CREDIT
Funding credit	It is intended to cover normal expenses of production cycles, from the purchase of inputs to the harvest phase.
Investment credit	It is intended for applications in goods or services whose benefit extends over several production periods. For example, in the acquisition of a tractor.
Marketing credit	It is intended to provide rural producers or cooperatives with the necessary resources to sell their products in the market.
Industrialization credit	It is intended for the industrialization of agricultural products, when carried out by cooperatives or by the producer on his rural property.

Source: Bacen (2022), adapted by the author 2022

In this context of rural credit purposes, Lopes *et al.* (2016) highlight that rural credit has especially financed the cost of production in recent decades, helping producers with grain production and/or livestock costs, soil preparation, seed planting, area cleaning and harvesting, among others. According to Alves (2018) Pronaf costing, it is clear the importance for food production and consequently increasing the income of family farmers who took this type of rural credit, highlighting that there were improvements in production after the implementation of the credit.

Also according to Lopes *et al.* (2016), these credit lines also helped in the promotion of products by enabling the financing of fees and costs related to the Rural Product Note (CPR). For Stoffel *et al.* (2015) credit as a public policy creates opportunities for farmers to fund their activity, increase and improve production, consequently increasing the producer's income.

Verlich and Costa (2013) show that the credit analysis process especially includes: creation of a rural project or a credit plan; later the registration of the borrower is carried out or

updating if it exists in the financial institution; after registration the proposal is registered generating a risk classification, taking into account the current restrictions, as well as the time in the field of activity; After the rural credit proposal is generated, it is immediately submitted to the competent authority. Also for Santos *et al.* (2020) The process to obtain rural credit is divided into 3rd stages, as shown in Table 2:

Table 2

Stages to obtain rural credit

STEPS TO OBTAIN RURAL CREDIT	DESCRIPTION
Step 01 - Documentation	At this stage, the credit contracting process begins and the requested documents are presented. According to the authors, the main documents requested are: personal documents (RG, CPF, Marriage Certificate, Proof of Income, Producer's Card and Proof of Residence.), property documents (Rural Property Registration, DAP, Lease Agreement, Rural Territorial Tax (ITR), Rural Property Certificate (CCIR), documents of real estate and movable property.), and Technical documents that prove the activity that the producer carries out (Agricultural or livestock production and sanitary record.)
Stage 02 - Preparation of the rural project	The authors address in this step the step-by-step of how to proceed with the elaboration of the rural project.
Step 03 - Formalization of the proposal	At this stage, the signature of the banknote, approval of the credit, receipt of the resource and application in the activity occurs.

Source: Santos *et al.*, (2020), adapted by the author (2022)

Credit lines are financial limits made available to individuals and companies through loans or financing, and are commonly granted for a specific purpose (UNIFOR, 2020). Each financial institution can join the credit lines to be worked on by financial institutions.

According to Santos (2019), specifically in the context of rural credit, financial agents can impose conditions for granting credit, such as: having the DAP form; not have restrictive annotations; and maintaining a good relationship with the financial institution can be a factor that influences obtaining higher credit limits. In this sense, Ferreira (2010) expresses that income, bank credit lines, commercial operations, terms of operations and investments should be highlighted for the decision to grant rural credit.

Wojciechowski *et al.* (2014) highlight that the granting of credit tends to be more accessible to producers who present their ecologically correct techniques, thus demonstrating commitment to sustainable development. According to the authors, the process of granting credit should be done in a sustainable way (better rates, grace period and longer terms) to producers who are committed to the socio-environmental issue.

According to table 3, it presents the commercial lines that family farmers can access in the Sicoob Centro cooperative.

Table 3

Sicoob center commercial credit lines

COMMERCIAL CREDIT LINES	DESCRIPTION
Small Producers Credit	The "Small Producers Credit" is a credit intended for individuals who carry out rural activities and who have a valid Declaration of Aptitude for Pronaf (DAP) certificate. This credit is granted under the condition of growth of the activity with an interest in the development of the agribusiness chain.
Agro Credit	Credit intended for the group of individuals who work in rural activity or professionals who provide services to agribusiness. The credit is granted under conditions for the growth of the activity with an interest in the development of the agribusiness chain.
Rural Promissory Note (NPR) Advance	Credit line intended for anticipation of credit sales to rural producers who have their own production, through the promissory notes that the producer issues when they make credit sales
Women in the Countryside	Line intended for female rural producers, to purchase items to improve the activity they perform. It has the purpose of purchasing inputs or production items, such as: machinery, tools and irrigation.
Revolving Credit	Line of credit whose limit is pre-approved for the borrower who can apply as needed.

Source: Sicoob Centro (2022), adapted by the author (2022)

In addition to commercial lines, producers also have Pronaf as an option for financing rural activity in several financial institutions (such as Sicoob Centro) in Brazil.

2.3.1 Pronaf

The National Program for the Strengthening of Family Agriculture (PRONAF) is a public policy adopted in Brazil. Several financial institutions in the country operate PRONAF, including Sicoob Centro.

According to Crisa *et al.* (2014, p. 324):

Created in 1995, the National Program for the Strengthening of Family Farming (Pronaf) marks the Brazilian State's recognition of family farming. From regional programs that little recognized the economic importance of the social category – historically treated as subsistence producers, small farmers or low-income producers – family farmers now have a national policy aimed exclusively at them.

PRONAF has numerous classifications regarding credit. According to the Rural Credit Cooperative with Social Interaction (CRESOL, 2021), there are several subdivisions of Pronaf that can meet the needs of each producer, as shown in table 4:

Table 4

PRONAF modalities

PRONAF modalities	Description
Pronaf Costing	Divided into agricultural and livestock. In the agricultural sector, the financing is intended for the productive period of the crops, in the livestock sector, the cost is used for the exploitation of livestock.
Pronaf Investment	Intended to finance rural agricultural and non-agricultural activities, aiming at increasing income generation and better use of family labor.
Pronaf More Food	Specifically aimed at permanent improvements, such as construction, renovation and expansion of machinery.
Pronaf Woman	Specific financing for production companies, specifically aimed at permanent improvements, such as construction, renovation and expansion of machinery.
Pronaf Bioeconomy	Financing for environmental adaptation projects, implementation of nurseries, construction or expansion projects, renewable energy technologies.
Pronaf Agroindustry	Aimed at family farmers and cooperatives, for application in processing, agricultural marketing, artisanal and forest products.
Pronaf Agroecology	Intended for funding related to the implementation and maintenance of agricultural production systems.
Pronaf Youth	Its purpose is to invest in production activities, the beneficiaries are young people between 16 and 29 years old.
Pronaf Microcredit	Destined for rural producers, who had a gross income of up to 23 thousand.
Pronaf Shares	Financing for the payment of shares for producers associated with credit cooperatives.
Pronaf Forest	Credit That has for the purpose of ecologically sustainable extractive exploitation.
Pronaf Semi-arid	Used in semi-arid regions, to finance water infrastructure projects.
Pronaf Industrialization of Family Agroindustry	Its objective is to finance storage, acquisition of packaging and acquisition of inputs. Financial institutions have different lines of credit, which small producers can use depending on their activity in rural areas, whether to use in costing, investment, commercialization or industrialization.

Source: Cresol (2021), adapted by the author (2022)

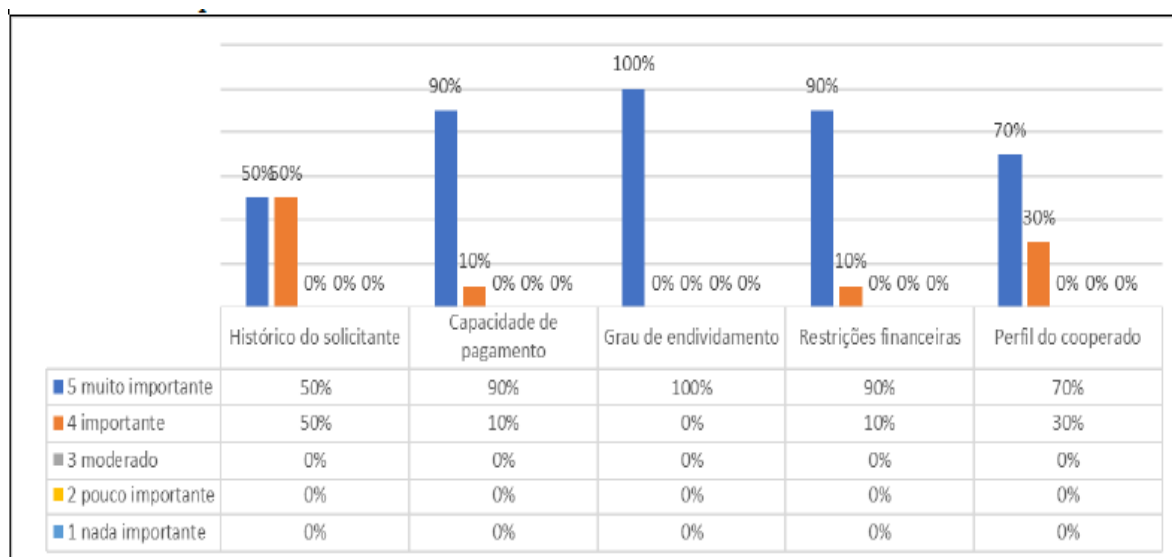
Through the Pronaf modalities, family farmers can choose the credit modality based on the need for application, which can be in costing, investment or marketing.

2.3.2 Credit Restriction

Rural producers, when seeking access to rural credit, go through an analysis process, thus being able to have their credit approved or denied by the financial institution. According to Assunção and Alves (2007), one of the main bottlenecks in credit analysis is the lack of registration information on the part of the credit applicant. There is a major obstacle related to credit rationing, which relies on the scarcity of data to measure the real condition of those who use it (ASUNÇÃO; ALVES, 2007). For Schroeder (2021), the factors that influence the granting of credit, based on the criterion of priority in the granting of credit, are especially those evidenced in figure 1:

Figure 1

Importance of registration queries



Source: Schroeder (2021)

According to data collected by Schroeder (2021), it can be seen that the degree of indebtedness is the main factor that influences the granting of credit, followed by financial restrictions and payment capacity.

Other common problems for small rural farmers are the lack of knowledge about rural credit and the absence of collateral, with the lack of information to financial institutions that do not feel safe and make it difficult to access credit. For Mundo Neto and Souza Filho (2015), the costs of operations of special rural credit programs tend to increase when financial institutions are not interested in operating with family farmers, making it difficult for farmers to access them by requiring real guarantees for loan or financing approval.

The main problems related to credit operations can be described as shown in table 5:

Table 5

Problems related to credit operations by family farmers

Problems Related to Credit Operations
Lack of information about credit.
Difficulty in evaluating the assets, considering the risks and payment conditions.
Meet the requirements linked to each credit.
Lack of relationship with financial agents.
Risk aversion.
Opposition between financial agents and borrowers.
High costs for formalizing the contract, due to the time spent and travel to the financial institution.

Source: Mundo Neto (2004), adapted by the author (2022)

According to data from the research by Lima *et al.* (2019), the main factors restricting PRONAF credit are: lack of technical assistance, excess of documents to be forwarded, registration restriction, lack of information from family farmers about the credit and default by the family farmer.

Also according to research carried out by Mundo Neto (2004), there are some factors in the lack of understanding between institutions and borrowers, as shown in table 6:

Table 6

Problems related to credit operations by family farmers

Reason for Lack of Understanding Between Institutions and Borrowers
Lack of knowledge about credit lines, especially those aimed at Family farming
High banking requirements
Scarcity of information on the part of the government, for not informing the possibilities of Funding
The bank's lack of interest in working with family farmers
Farmers' fear of taking credit and losing their assets to banks

Source: Mundo Neto (2004), adapted by the author (2022)

The concession is extremely important for the small farmer, but the factors that can lead to a credit restriction must be observed when seeking a resource from a financial institution.

2.4 COOPERATIVISM

For the Organization of Cooperatives of Brazil (OCB, 2022), cooperativism is a doctrine of life that aims to change the world, making it a fairer, more balanced and happier place with better opportunities for all. The principles of cooperativism are divided into seven pillars, namely: Voluntary and free membership; Democratic management; Economic participation of members; Autonomy and independence; Education, training and information; Education, training and information and Interest in the community.

For Costa (2006), cooperativism is a social movement that occurred at the time of capitalism, when terrible working conditions were at their peak, caused the conflicts between capital and the working class to give rise to a new model of organization, thus giving rise to cooperatives.

Cooperativism emerged in the middle of 1844, in the city of Rochdale-Manchester, England, when 28 workers came together to create their own warehouse. Four years after its creation, the cooperative had more than 140 members. The cooperative adopted moral principles that guide it to this day, including solidarity, honesty, equity, and transparency (OCB, 2022).

2.4.1 Credit Unions

Gradually, individuals and companies are looking for services provided by credit unions, especially because of the rates offered and lower service costs than banking services. Cooperatives are financial institutions regulated by the National Monetary Council (CMN) and supervised by BACEN (BRESSAN et al., 2010).

According to Law No. 5,764, of December 16, 1971 (CONGRESSO NACIONAL, 2022), cooperatives are partnerships of people, with their own corporate aspects, of a civil nature, developed to provide services to members and are not subject to bankruptcy. Specifically as financial institutions, credit unions have the following main characteristics: Voluntary adhesion; Share capital represented by shares; Singularity of vote; Return of leftovers at the end of the net year; Provision of assistance to cooperative members.

For Pesente (2019), cooperatives are non-profit institutions that can result from the association of professionals in the same field, joining companies, employees of the same company, and must have at least 20 cooperative members. Regarding operations, credit unions especially capture demand and term deposits (only for members), loans and financing. In this way, the credit union can only provide services to member members.

As for the classification of credit unions, according to the National Cooperative Policy described by the National Congress (2022), they can be classified as:

Singular: formed by individuals, excessively relating to organizations that have the same objective or establish economic or non-profit relations;

Central Cooperatives or Federations of Cooperatives: They must be constituted by at least 3 individuals, and may admit individual members;

Confederations of Cooperatives: made up of at least three federations of cooperatives or central cooperatives.

Cooperativism provides a viable alternative for those who seek to reduce costs, be able to compete with other companies or seek better alternatives for access to credit.

2.4.2 Sicoob Credit Cooperative

The Credit Cooperative System of Brazil (Sicoob) is made up of credit cooperatives, as well as qualified technical assistance companies. Through the cooperative's organizational model, divided into singular, central and Sicoob Confederation cooperatives, cooperatives have access to technological infrastructures, auditing, communication and marketing services, ombudsman and relationship with the cooperative. Through this model, Sicoob cooperatives share policies, standards, conducts, technologies, products, services and brands, thus standardizing the process and gaining efficiency throughout the Sicoob system (SICOOB NACIONAL, 2022). The Systemic structure that integrates Sicoob, according to Sicoob Nacional (2022) is: Cooperative Bank of Brazil (Bancoob) and Regularizing Companies: electronic means of payment companies, consortium entities, insurance and pension companies, entities that provide products and services.

According to the Sicoob Nacional system (2022), the Sicoob credit cooperative operates in 350 Brazilian municipalities, with 351 singular cooperatives and more than 6.5 million active cooperative members.

In addition, financial cooperatives have the protection of the Credit Cooperativism Guarantee Fund (FGCoop). The objective of this fund is to ensure the protection of depositors and investors of credit unions, thus equalizing the conditions of competitiveness with commercial banks (SICOOB COOPERCREDI, 2019).

3 METHODOLOGY

Methodology is the process by which the researcher demonstrates the processes that will be used in his research. Therefore, in this section the methodological characteristics of the study will be presented.

The present research is characterized by the descriptive type, as it aims mainly to analyze the main factors of credit restriction experienced by family producers in the cities where the credit cooperative Sicoob Centro operates. According to Prodanov and Freitas (2013), descriptive research aims to characterize a certain population or phenomenon, or to establish relationships between variables.

The work adopted the deductive method for the analysis of the research, so logical reasoning was used for the interpretation and verification of the data. According to Descartes

(2003), the deductive method presented a modern way of carrying out scientific research, denying oneself from the supernatural and dedicating oneself to the maximum through reason when seeking knowledge that is titled as true.

As for the approach, qualitative research was used, as it was necessary to understand the reason for certain behaviors. For Bauer and Gaskell (2002), qualitative research is the diversity of representations of people in their experiential world. For Deslauriers (1991), the researcher is the element and object of his own research.

Regarding the data collection techniques used, in this study we used bibliofigural, documentary and field research. Gil (2002) comments that the bibliofigural research constitutes materials already prepared on the subject by other scientists, such as published books, articles and magazines.

As for documentary research, for Cellard (2008), this technique is used by original manuscripts. Helder (2006) says that it is an indisputable technique for research in the social sciences. According to Sá-Silva *et al.* (2009) documentary research uses materials that have not received analytical treatment, while bibliofigural research refers to works by different authors who have already studied the subject.

For Vieira and Lugli (2015), field research aims to understand and clarify the researched problem, based on a theoretical basis. Research acts through the observation of events and phenomena exactly as it happens in reality, proceeding from the analysis and interpretation of these data.

The bibliofigural research was elaborated through scientific articles, books, magazines and websites of financial institutions, considering the reliability of the sources and data. The documentary research was carried out with the credit union, as it followed the use of manuals and internal regimes regarding credit lines, as well as spreadsheets with the registration information of rural producers made available by the credit cooperative Sicoob Centro.

For the field research, a questionnaire (APPENDIX A) was used, containing 14 questions, which were open questions, which were filled out without the presence of the researcher. The questionnaire was applied from September to November 2022, with credit analysts, managers, and employees who worked for at least one year in the aforementioned functions of the institution. According to Parasuraman (1991), the questionnaire is composed of questions, aiming to collect data necessary to solve the problem.

The research subjects were 13 employees of the Sicoob Centro institution who work in the credit and credit analysis committee, and the employees who worked for at least one year in these functions of the institution. In this way, because the investigation is carried out with all

the members of the credit committee, the survey will be of population, or also known as census. In census research, it is essential to verify all the data of 100% of the participants (KHAN ACADEMY, 2022).

According to Flick (2009), ethics is the set of principles and convictions that guide the behavior of the individual in a given time or society. All participants signed the Informed Consent Form (ANNEX A), and they were not identified, and could be coded from A1 (Credit Analyst 1) to A13 (Credit Analyst 13).

The research also includes the Disclaimer (ANNEX B) in which the researcher completely exempts the Federal University of Rondônia Foundation (UNIR) - Professor Francisco Gonçalves Quiles Campus in Cacoal, the advisor and the professors indicated for composing the act of face-to-face defense, of full responsibility for all content or idea expressed, being able to respond civilly, or criminally in case of proven plagiarism.

The present research was carried out at the Sicoob Centro Credit Cooperative, with administrative headquarters in the city of Ji-Paraná, state of Rondônia. Currently, the cooperative operates in 10 municipalities in the state of Rondônia, with 17 physical branches and one digital branch. Thus, the research was carried out in the municipalities of Ji-Paraná and Jaru, cities in Rondônia where the members of the credit and credit analysis committee work.

According to the IBGE (2020), the city of Ji Paraná has a population of 130,009 people, with a territorial area of 6,897 km² and a demofigureic density of 18.7 inhabitants/km². Also according to the IBGE (2021), the city of Jaru has a population of 51,469 people with a territorial area of 2,944,128 km² and 17.66 inhabitants/km². The employees of the concession and credit analysis of Sicoob Centro are the targets of this research.

4 RESULTS AND DATA ANALYSIS

In this topic, the results obtained during the research carried out through a form with the credit analysts of Sicoob Centro will be presented, with the purpose of achieving the objectives of this work, in particular to analyze the main factors of credit restriction experienced by family producers in the cities where the Sicoob Centro credit cooperative operates.

4.1 PROFILE OF SICOOB CENTRO'S BORROWERS

Analyzing the survey data, it was found that 100% of the participants stated that family producers are part of the institution's credit policy, being one of the main audiences served, as it is the majority in rural credit concessions carried out by the Sicoob Centro cooperative. Based

on this statement, initially the survey collected data on the profiles of rural producers, through the active credit portfolio of the Sicoob Centro cooperative. Therefore, the main results are the data presented in table 7, as follows:

Table 7

Profile of family producers

ITEM INVESTIGATED	MAIN RESULTS	ANALYSIS/COMPARISON
Age producers	14,52% have Age between 44 and 48 years old, 13.88% from 39 to 43 years old and 12.96% from 34 to 38 years old.	According to data from the IBGE survey, in 2017 it was found that the predominant age group of producers is over 55 years old.
Main areas of activity	67.16% work in beef cattle, 22.71% in dairy cattle and 1.67% in beef cattle farming. coffee, 3.46% other modalities.	According to Pfeifer et al. (2021), agriculture and livestock are central axes of the Rondônia economy, with coffee, corn, rice and soybeans being highlights in agriculture and livestock the production of beef and dairy cattle.
Average monthly income	R\$ 17.443,22	According to the survey by the Supply Company (CONAB) in 2019, family farming suppliers in the northern region had an average income of R\$ 6.833,11.
Main lines active credit cards	91% represents PRONAF Costing and Pre-Costing, while 9% of the active portfolio represents Pronaf Investment, Capital of Giro and Agroindustry.	In an investigation carried out by Dornelles (2019), regarding the purpose of the credit, it was identified that 50% of the credits are granted for investment, 45% for funding and 5% for commercialization.

Source: data from the survey itself, 2022.

Reaffirming what was exposed by Alves (2018), Pronaf costing is of significant importance for food production and consequently increased the income of family farmers who took this type of rural credit, and it is highlighted that there were improvements in production volumes after the implementation of the credit.

The data made available by the financial institution also point out that currently (2022) they have about 1736 active contracts, of which 86.69% are taken by male producers, while 13.31% are female. Regarding the gender of the borrowers, it is clear that the data found in this research are similar to the data obtained in the research by Oliveira (2016).

4.2 MAIN CREDIT LINES OFFERED AND DEMANDED AT THE SICOOB CENTRO CREDIT COOPERATIVE

Table 8 shows the main lines of credit offered by the Sicoob Centro cooperative to family farmers, as reported by the research participants.

Table 8

Main credit lines offered

CREDIT LINES	NUMBER OF TIMES MENTIONED BY RESPONDENTS
PRONAF COSTING	10
AGRO CREDIT	9
PRONAF INVESTMENT	9
NPR ANTICIPATION	3
BNDES BUSINESS CARD	3
FREE OWN RESOURCE (RPL)	3
WORKING CAPITAL	2
REVOLVING CREDIT	2
WOMEN IN THE COUNTRYSIDE	2
PRONAF	2
CPR-F – RURAL PRODUCT NOTE FINANCIAL	1
SMALL PRODUCERS CREDIT	1
SOLAR FINANCING	1
VEHICLE FINANCING	1
SMALL PRODUCER LINES	1
PCA - CONSTRUCTION PROGRAM AND EXPANSION OF WAREHOUSES	1

Source: data from the survey itself, 2022.

As obtained through the registration information made available by SICOOB Centro (table 1), according to the interviewees, PRONAF Costing is the main line of credit made available to family farmers. This information, therefore, is in line with the statement of Lopes *et al.* (2016), which explains that in recent decades rural credit has uniquely financed costing credit, helping producers with production costs, cleaning of the area and harvesting, among others.

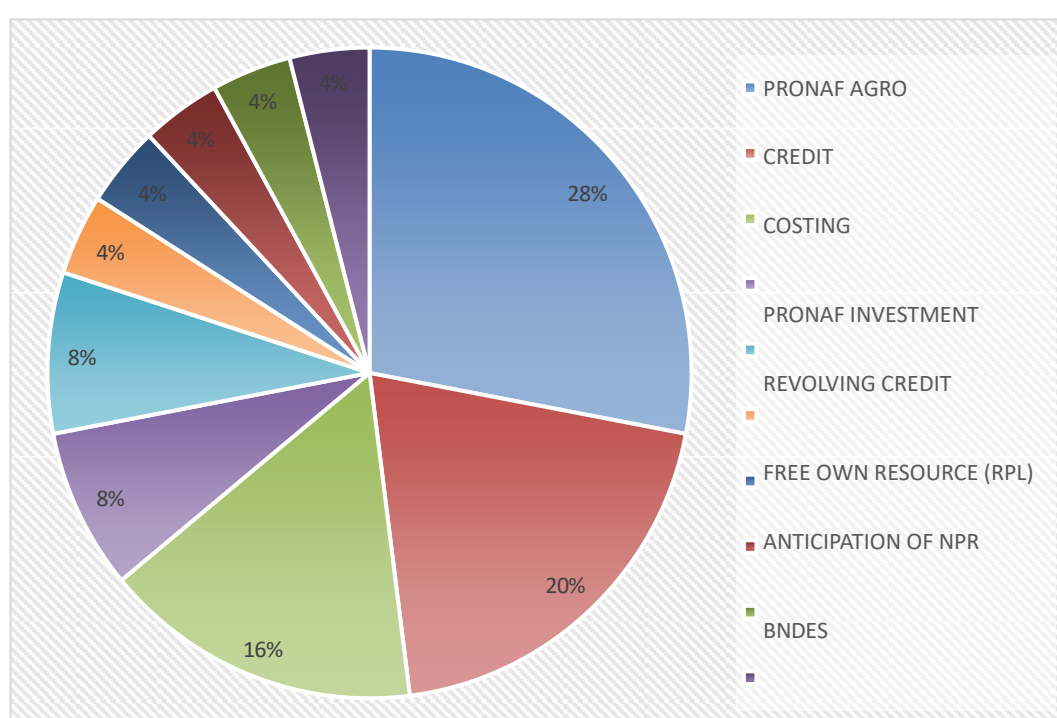
It is noted that other lines of credit mentioned by the interviewees are not rural credit lines offered with state subsidies, such as Crédito Agro, a commercial line of the Sicoob Centro cooperative itself. Pronaf allowed farmers to have access to rural credit, thus presented as a more effective alternative for Brazilian family production, but not all farmers can access this credit, due to the amount made available by the government in the crop plan being insufficient to serve all producers. When the family producer is unable to access credit, he resorts to the commercial lines of financial institutions, which in turn present rates, payment terms and other attractive factors for the producer to take this credit, but not always as attractive as those

available through PRONAF. Another situation mentioned by the interviewees is when the family farmer needs the resource immediately. In this case, it is common to use the NPR Anticipation and Revolving Credit credit lines, viable alternatives for the producer who needs the resource more urgently.

In addition to determining the main rural credit lines operated by the cooperative, it was also investigated which are the credit lines most demanded by producers, in the perception of the interviewees. Therefore, it was questioned which would be the credit lines most requested by family producers, and in figure 2 the results obtained are shown:

Figure 3

Main credit lines made more expensive by family producers



Source: survey data, 2022.

It can be seen that the three most demanded credit lines, in the perception of the interviewees, are the same ones most offered by the credit union. When asked why these credit lines are the most requested, A1 points out that "because it is an incentivized credit line and is a resource for passing on, interest rates and the term are more attractive". The A6 also adds that "those with government funding due to low rates, but when the concession limit is exceeded to the agro credit line". It is observed that the Agro Credit is used as a second alternative when the producer cannot access the lines encouraged by the government. A12 also reinforces that "the main demand of rural producers is funding and revolving credit to maintain emergency

expenses". Both agro credit, NPR anticipation, revolving credit, are more accessible lines to small producers, even with divergent rates from rural credit lines.

Also asked if the credit lines, volumes and conditions available meet the needs of family producers, the interviewees answered as shown in table 9:

Table 9

Conditions provided by financial institutions

INTERVIEWEES	ANSWERS
A1	I believe that if a greater amount of resources were made available, producers would be better served.
A2	Yes.
A3	Yes, since most of our focus is directed to rural producers.
A4	Yes.
A5	Attendant perfectly and we managed to do financial justice.
A6	Yes.
A7	Yes, they are lines designed properly in the financial lives of producers, considering the instabilities of the market.
A8	Yes.
A9	Yes.
A10	Yes.
A11	More or less, because the policy until the release of the resource is very bureaucratic, where some producers are somewhat prevented from securing a resource
A12	No response.
A13	Yes. The main impediment is the documentary issue because our state is very lacking in environmental and land regularization, there is also a lack of competence, inspection of the public and federal agencies responsible for issuing Mandatory rural credit documents.

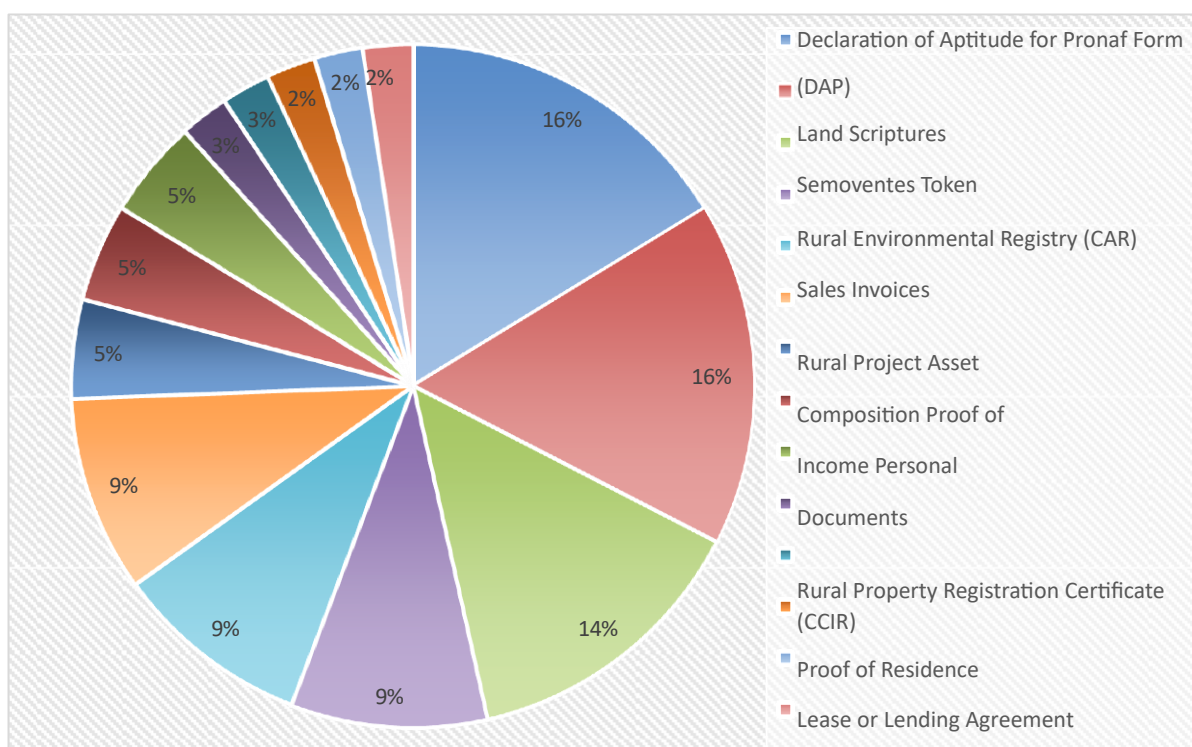
Source: survey data, 2022.

The results obtained reaffirm what Mundo Neto (2004) expressed about the high banking requirements.

According to Crisa *et al.* (2014) small farmers were treated as subsistence or low-income producers, but after the creation of Pronaf, family farmers began to have an exclusive credit policy, which has contributed to the promotion of rural activity. Pronaf guarantees improvements in the quality of life and generates opportunities for family farmers.

4.3 CREDIT ASSESSMENT PROCESS

Subsequently, he was investigated about the documents required by the credit union during the credit assessment process. The result on the question about which documents or data is required by the institution for credit evaluation/analysis are presented in table 02, below:

Figure 4*Documents/data required in the credit analysis*

Source: survey data, 2022.

The data in figure 02 shows a high demand in relation to the documents to be presented when the family farmer seeks access to credit. Mundo (2004) comments that high banking requirements make it difficult to access rural credit. It can be seen that the DAP form is the main document required, in accordance with Brasil (2022), which mentions that family farmers need to issue the DAP to have access to public rural credit policies. The importance of DAP in the process of access to rural credit is in line with the statement made by Santos (2019). The results shown in Table 3 are also in line with those described by Santos *et al.* (2020) when they address the documentation required to access rural credit.

Another question raised was whether family farmers were able to meet the demands of the cooperative, among the main answers according to the interviewees are: interviewee A1 stated that "producers can deliver documentation easily.". On the other hand, interviewee A11 states that "in certain situations producers do not have all the documentation of the property, and do not have a real guarantee to offer in the proposal". Also according to interviewee A13 "many producers do not have these documents due to the lack of land and environmental regularization in our state".

In general, according to the interviewees there is no distinction in the credit analysis, regardless of the size of the producer, they all went through the same analysis, what will change

is the documentation required for each size according to the rural credit manual, the rates in each type of credit and especially the payment conditions of the borrower, because the credit will only be granted if the producer is able to honor the commitment to settle the rural credit operation.

When asking the interviewees about the credit analysis process of a family farmer in the institution, it is possible to divide the process into 6 (six) stages, as shown in table 10:

Table 10

Stages of credit analysis according to interviewees

STEPS OF CREDIT ANALYSIS	DESCRIPTION
STEP 01	Producer Search Assists Techniques or cooperatives and presents its demand.
STEP 02	It is necessary to create a feasibility project and present it to the cooperative.
STEP 03	The branch manager registers the proposal, technical data, uses the credit manual to define rates, operating conditions, payment frequency, among other relevant factors.
STEP 04	Subsequently, the data is passed on to the credit analysis sector, which will gather all the data (financial, personal, income, assets, among others) in a single document, identifying if there is any divergence according to the rules of the credit manual.
STEP 05	After the conclusion of the credit analysis, the proposal arrives at the credit committee sector, which will analyze all the data delivered by the analysis and decide whether to grant credit to the borrower.
STEP 06	When deciding to proceed with the proposal, it is forwarded to the release sector responsible for formalizing the credit (signing the contract).

Source: survey data, 2022.

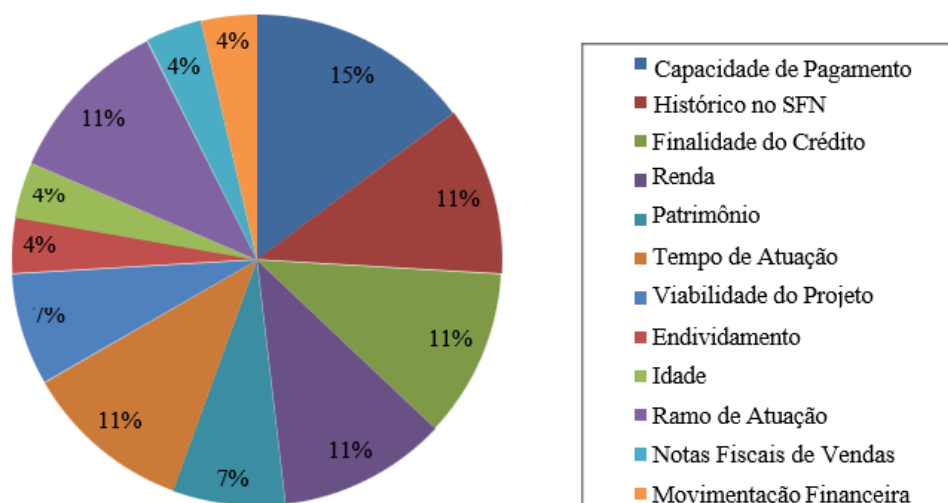
The process of analysis of rural credit carried out at the credit cooperative Sicoob Centro is similar to the process of credit analysis exposed by Verlich and Costa (2013). However, it should be noted that the steps of the credit analysis process adopted by Sicoob Centro differ from what was proposed by Santos *et al.* (2020), where they present more objective stages.

When asked if they believed that there could be another valid process(es) for credit analysis of family producers, interviewee A1 replied that "I believe that there may be other means, but I do not know the process". A3, on the other hand, replied that "yes, photofigureic reports, and field visits". Respondents A6, A8, A9 and A11 stated that there are no other valid processes for the analysis. Other interviewees did not respond.

When asked what are the most relevant points for the evaluation of the credit of a family farmer, figure 5 presents the answers of the interviewees.

Figure 5

Main points analyzed in the rural credit assessment



Source: survey data, 2022.

According to the data obtained, the main points to be analyzed when a family farmer seeks credit at the Sicoob Centro credit cooperative are: Payment capacity, History in the National Financial System, Purpose of Credit and the producer's income. It is also possible to highlight the verbalization extract of interviewee A13 who states "many cases of losses in rural credit are due to the misuse of credit and deviation of purpose". The data obtained are in line with the results obtained by Schroeder (2021). The author identifies that the degree of indebtedness is the main factor that influences the granting or not of credit, followed by financial restrictions and payment capacity.

Next, the main factors restricting rural credit by the credit union during the credit evaluation process were investigated. The result of the questioning was shown in table 11, below:

Table 11

Main factors restricting rural credit

INTERVIEWEES	ANSWERS
A1	Sometimes the delay in granting credit makes producers give up.
A2	No response.
A3	Lack of information about the performance of the cooperative, and also their high indebtedness, in view of the low @ of cattle.
A4	No response.
A5	Lack of formality.
A6	Lack of knowledge about the credit conditions offered by Sicoob.
A7	Without financial capacity, relevant restrictions in the financial system and without technical capacity (does not have assets with the capacity to supply the operation).
A8	High indebtedness. And with restrictions in force.
A9	High indebtedness.

A10	To be a borrower, to already have other loans.
A11	The requirement of some documentation.
A12	No response.
A13	No response.

Source: survey data, 2022.

According to the data obtained in table 08, it can be highlighted that high indebtedness, lack of information about the borrower, delay in granting credit, the requirement of some documentation and not having assets to supply the operations, are pointed out as the main factors restricting rural credit with the credit cooperative Sicoob centro. Based on the answers of the interviewees, it is noted that the results are similar to data from the research by Lima *et al.* (2019), regarding the main factors restricting PRONAF credit. According to Lima *et al.* (2019) lack of technical assistance, excess of documents to be forwarded, registration restriction, lack of information from family farmers about credit and default by family farmers may also be factors that restrict credit. It can be concluded that in addition to the factors exposed by the interviewees, there are other factors that can lead to restriction of rural credit.

It is also worth highlighting the considerations made by Mundo Neto (2004). According to the author, the lack of understanding between institutions and borrowers can be explained through the following factors: lack of knowledge about credit lines, especially those aimed at family farming; high banking requirements; scarcity of information on the part of the government, for not informing the possibilities of financing; the bank's lack of interest in working with family farmers; farmers' fear of taking credit and losing their assets to the banks.

4.4 QUALITIES OF THE INFORMATION PROVIDED FOR TAKING CREDIT

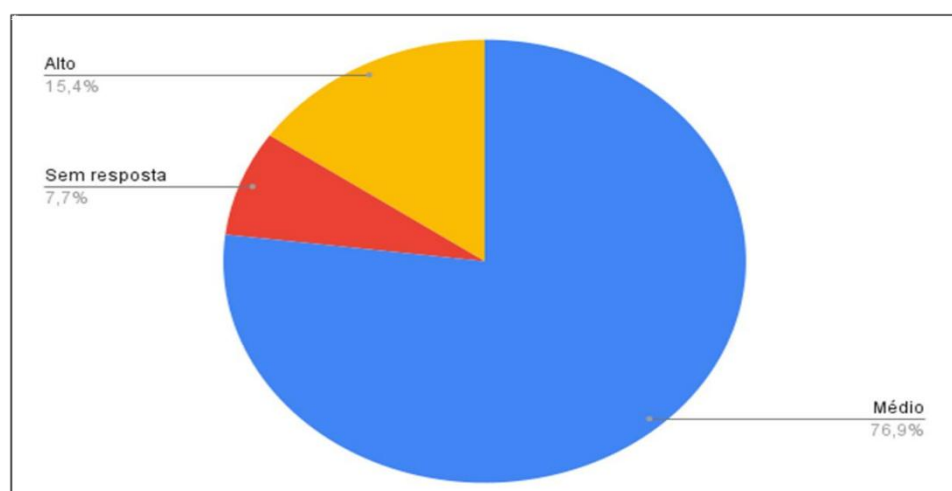
When asked if cooperatives, unions, government or other entities could take other actions by family producers to favor access to credit and reduce financial costs, the following result was obtained as shown in table 12:

Table 2*Actions to promote access to credit*

INTERVIEWEES	ANSWERS
A1	Yes, credit policies aimed at the small producer, more humble and less educated.
A2	Yes, partnerships could be made with a view to greater dissemination of the lines of credit.
A3	No response.
A4	Yes, with several projects and offers.
A5	No.
A6	Yes, the agricultural area is constantly changing and in the same way institutions must change aiming at the benefit of the producer based on the moment wherever he is.
A7	No.
A8	Yes.
A9	Yes.
A10	Yes, to give more credibility to the small producer, where he would have a Greater ease when setting up a project.
A11	No response.
A12	Yes. Creating a unification of documents such as a single register of rural producers that already includes all the data of family producers and including their production, and that meets the requirements of the credit manual rural, facilitating the gathering of documents.
A13	No response.

Source: this research, 2022.

Next, figure 6 presents the data according to the interviewees, when they were asked about the level of reliability (high, medium or low) of the information in the data provided by family producers.

Figure 6*Reliability of information*

Source: survey data, 2022.

Still when asked if there is any information(s) with a low level of reliability, what would this data be, interviewee A3 answered that "there are situations in which we cannot trust the data received, for example, the cattle file, there is a very high ease of transferring cattle from one file to another." While A13 reported "the DAP is a document of paramount relevance, but which, however, is not in the vast majority reliable, due to the agents of the responsible entities manipulating the producer's data for the proper framing of the rules". Although regulatory bodies have data protection laws, internal rules, it may happen that documents are fraudulent by those who have the power to change it.

5 FINAL CONSIDERATIONS

The research sought to highlight the main factors that restrict the granting of rural credit to family farmers by the Sicoob Centro cooperative. In addition, it was sought to describe the profiles of the borrowers, the characteristics of the main credit lines taken, the credit process and evaluation, and to describe the quality of the information provided for taking credit. Therefore, it is noted that the objectives of the work were achieved.

The study found that the profile of the producers was 86.69% male and 13.31% female, with a predominant age between 44 and 48 years, working with 67.16% mainly in beef cattle farming, 22.71% in dairy cattle farming.

The main rural credit lines offered by Sicoob Centro are Pronaf Costing, investment and Agro Credit, which are the same most demanded by family farmers in the perception of the interviewees, taking into account the rates available and payment conditions. Crédito Agro is being used as a second alternative for producers who cannot access the lines made available by the government.

The survey also pointed out that for the interviewees, the main documents required in the credit analysis are: DAP form, rural property deeds, semoventes form, CAR, sales invoices and rural project, among others. Therefore, it is noted that the cooperative has a high requirement regarding documentation. Another point observed, for the interviewees, is that there is no distinction regarding credit analysis, regardless of the size of the rural producer, what differs is the documentation required according to the rural credit manual.

When the credit analysis process begins, it is noted that the first step is for the producer himself to seek the cooperative or technical assistance, then the feasibility project is created, because it will be through this project that analysts can analyze whether it will be feasible to grant credit. For the credit analysis, the interviewees say that photofigureic reports and field visits can help facilitate access to rural credit.

Another point immensely identified is the main points analyzed in the evaluation of rural credit, where the main points cited by the interviewees were the ability to pay with 15%, with 11% history in the SFN, 11% purpose of credit, 11% income, 11% time of operation and 11% of branch of activity. The survey found that when credit losses occur, it is due to misuse and deviation from the purpose.

During the study, it can be concluded, according to credit analysts at Sicoob Centro, that the main factors restricting credit are high indebtedness with the current restrictions, lack of information about the borrower, delay in granting credit, the requirement of some documentation and not having assets to supply the operations.

When asked what actions could be taken by family producers to favor access to credit and reduce financial costs, the analysts said that field visits, keeping documents up to date and more clarity in the information granted to the cooperative, are actions that can facilitate access to credit, but the family farmer will go through all stages of credit analysis.

Still asked about the level of reliability of the information provided by the producers, 15.4% of the interviewees stated that the level is high, 76.9% medium and 7.7% low. It can be concluded that family farmers need to have more transparency in the data made available to credit unions.

After compiling all this information, it can be concluded that keeping the registration updated in financial institutions, being transparent in the documents requested, using credit for the proper purpose, having financial control so as not to have a high indebtedness and not having restrictions in force in the SNF, are actions that can overcome the main restrictions on access to credit.

For future work, it is suggested that the research be carried out considering the point of view of family farmers, demonstrating the difficulties they have to access the credit lines encouraged by the government. In this way, the cooperative will be able to identify bottlenecks in the credit analysis developed by the Sicoob Centro cooperative.

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ANNEX A: FREE AND INFORMED CONSENT FORM

You are being invited to participate, as a volunteer, in the research on **THE FACTORS OF RESTRICTION TO RURAL CREDIT FOR FAMILY FARMING**. And if you agree to participate, please sign at the end of the document. Your participation is not mandatory, and at any time you may withdraw from participating and withdraw your consent. Your refusal will not cause any harm to your relationship with the researcher or the institution.

You will receive a copy of this **term** with the researcher's telephone number and address, and you can ask questions about the project and your participation.

PROGRAM: Degree in Business Administration at UNIR – Federal University of Rondônia Foundation.

RESEARCHER IN CHARGE: Wendel Saymon Batista da Silva. **ADDRESS:** Av. Espírito Santo, 719. Novo Horizonte neighborhood. Cacoal-RO. **PHONE:** (69) 9 9245-8652

OBJECTIVES:

Analyze the profile of family producers who contract rural credit at Sicoob Centro;

Survey the main credit lines used by rural family producers in the Sicoob Centro Credit Cooperative;

Identify the factors that contribute to access and restriction of credit for small rural producers in the Sicoob Centro Credit Cooperative;

To ascertain together with Sicoob Centro's credit analysts the actions that can minimize the restriction on PRONAF credit.

STUDY PROCEDURES: If you agree to participate in the survey, you will have to complete an electronic form. The collected data will be tabulated and analyzed for the conclusion of the undergraduate article of the Administration course at the Federal University of Rondônia – UNIR.

RISKS AND DISCOMFORTS: the research does not offer any risk or harm to the participant.

BENEFITS: to provide improvements in the process of granting rural credit to small farmers.

COST/REFUND TO THE PARTICIPANT: There will be no expense or payment with their participation.

RESEARCH CONFIDENTIALITY: Guarantee of secrecy that ensures your privacy regarding the confidential data involved in the research. The data and your name will not be disclosed.

Participant's Signature

ANNEX B: DISCLAIMER

Eu, **Wendel Saymon Batista da Silva**, DECLARO, para todos os fins de direito e que se fizerem necessários que isento completamente a Fundação Universidade Federal de Rondônia – Campus Professor Francisco Gonçalves Quiles em Cacoal, o orientador e os professores indicados para comporem o ato de defesa presencial, de toda e qualquer responsabilidade pelo conteúdo e ideias expressas no presente trabalho de conclusão de curso. Estou ciente de que poderei responder administrativa, civil e criminalmente em caso de plágio comprovado.

Cacoal / RO, 12 de Dezembro de 2022.

Wendel Saymon Batista da Silva
Wendel Saymon Batista da Silva

APPENDIX

APPENDIX A - QUESTIONNAIRE ON RURAL CREDIT GRANTING INTERVIEW SCRIPT - FINANCIAL INSTITUTIONS

- 1) Are small rural producers part of the credit policy of this financial institution? Are you one of the main audiences served?
- 2) What are the main lines of credit – working capital, investment – offered/made available to small rural producers by the cooperative?
- 3) In your perception, what are the main lines of credit – working capital, investment – demanded/needed by small rural producers?
- 4) Do you believe that the volume, credit lines and conditions made available by financial institutions (not only by this cooperative) meet the needs of small rural producers?
- 5) Commonly, what data/documents are required by the financial institution for credit assessment/analysis of small rural producers? Are small rural producers always able to meet the requests?
- 6) In your perception, can the size of the producer favor, harm or be independent of access and cost of credit? Is there a distinction in credit analysis from small producers to large producers?
- 7) In summary, how is the credit analysis process of a small rural producer at the institution?
- 8) Do you believe that there may be another valid process(es) for credit analysis of small rural producers? If there is, what would it be like in your opinion?
- 9) Which point(s) is/are most relevant for the credit assessment of a small producer, in your opinion?
- 10) What are the main factors, in your perception, that restrict access to credit and/or increase financial costs in operations with small rural producers?
- 11) Therefore, in your opinion, what actions could be taken by small producers to favor access to credit and reduce the financial cost?
- 12) Do you believe that the cooperative, unions, government or other entities could take other actions to facilitate access to credit for small producers? If so, what stocks would they be?
- 13) What is your judgment on the level of reliability of the information provided by the data provided by small rural producers - high, medium or low? If there is any information(s) with a low level of reliability, what would it be?

14) If there is, what else is missing from general information from small producers for credit analysis?

INCREMENTAL AND RADICAL INNOVATIONS IN MICRO AND SMALL ENTERPRISES: EVIDENCE FROM THE ALI PROGRAM IN PERNAMBUCO

INOVAÇÕES INCREMENTAIS E RADICAIS EM MICRO E PEQUENAS EMPRESAS: EVIDÊNCIAS DO PROGRAMA ALI EM PERNAMBUCO

INNOVACIONES INCREMENTALES Y RADICALES EN MICRO Y PEQUEÑAS EMPRESAS: EVIDENCIA DEL PROGRAMA ALI EN PERNAMBUCO



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ABSTRACT

This article analyzes the impacts of technological and managerial innovations — classified as incremental or radical — on the productivity and survival capacity of micro and small enterprises (MSEs), based on the experience of the ALI (Local Innovation Agents) Program in Pernambuco, Brazil. Given the growing need for innovation strategies tailored to the profile of MSEs, an analytical model was proposed based on the adaptation of the Sectoral Innovation Degree (GIS), which led to the creation of the Incremental Innovation Degree (G²I). The study evaluated 48 companies using the Sebrae Innovation Radar, classifying 18 themes into technological and managerial axes according to their diffusion in the sector. The results show that approximately half of the indicators analyzed represent radical innovations, highlighting an untapped potential for disruptive practices. The G²I model proved to be a useful tool for diagnosing innovation maturity, guiding the prioritization of strategies, and supporting public innovation policies based on empirical and contextualized evidence.

Keywords: Radical Innovation. Incremental Innovation. Sectoral Innovation Degree. Micro and Small Enterprises. ALI Program.

RESUMO

Este artigo analisa os impactos das inovações tecnológicas e gerenciais — classificadas como incrementais ou radicais — sobre a produtividade e a capacidade de sobrevivência de micro e pequenas empresas (MPEs), a partir da experiência do Programa ALI (Agentes Locais de Inovação) em Pernambuco. Diante da crescente demanda por estratégias de inovação adaptadas ao perfil das MPEs, foi proposto um modelo analítico baseado na adaptação do Grau de Inovação Setorial (GIS), que deu origem ao Grau de Inovação Incremental (G²I). A pesquisa avaliou 48 empresas por meio do Radar de Inovação do Sebrae, classificando 18 temas em eixos tecnológicos e gerenciais, conforme sua difusão no setor. Os resultados revelam que aproximadamente metade dos indicadores analisados representa inovações radicais, o que evidencia um potencial subexplorado para práticas de ruptura. O modelo G²I demonstrou ser um instrumento útil para diagnosticar a maturidade

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inovativa das empresas, orientar a priorização de estratégias e subsidiar políticas públicas de estímulo à inovação com base empírica e contextualizada.

Palavras-chave: Inovação Radical. Inovação Incremental. Grau de Inovação Setorial. Micro e Pequenas Empresas. Programa ALI.

RESUMEN

Este artículo analiza los impactos de las innovaciones tecnológicas y gerenciales — clasificadas como incrementales o radicales— sobre la productividad y la capacidad de supervivencia de las micro y pequeñas empresas (MYPE), a partir de la experiencia del Programa ALI (Agentes Locales de Innovación) en Pernambuco, Brasil. Ante la creciente necesidad de estrategias de innovación adaptadas al perfil de las MYPE, se propuso un modelo analítico basado en la adaptación del Grado de Innovación Sectorial (GIS), que dio origen al Grado de Innovación Incremental (G²I). El estudio evaluó 48 empresas mediante el Radar de Innovación de Sebrae, clasificando 18 temas en ejes tecnológicos y gerenciales según su nivel de difusión en el sector. Los resultados revelan que aproximadamente la mitad de los indicadores analizados representan innovaciones radicales, lo que evidencia un potencial subutilizado para prácticas disruptivas. El modelo G²I demostró ser una herramienta útil para diagnosticar la madurez innovadora de las empresas, orientar la priorización de estrategias y respaldar políticas públicas de innovación basadas en evidencia empírica y contextualizada.

Palabras clave: Innovación Radical. Innovación Incremental. Grado de Innovación Sectorial. Micro y Pequeñas Empresas. Programa ALI.

1 INTRODUCTION

Innovation is widely recognized as an essential factor for the competitiveness and sustainability of companies, regardless of their size (Santos, 2020; Rajapathirana & Hui, 2018). However, micro and small enterprises (MSEs) face specific challenges to identify, absorb and apply innovative practices that are aligned with their stage of maturity and management capacity. In this context, it becomes crucial to distinguish between incremental innovations—which improve existing practices—and radical innovations—which represent significant disruptions in organizational or technological models.

The literature on organizational innovation has evolved from a unitary approach to a dichotomous view, recognizing different types and intensities of innovation (Dewar & Dutton, 1986; Lennerts et al., 2020; Johnson, 2020). Despite this theoretical evolution, there is still a gap in the empirical operationalization of indicators that allow objectively classifying the type of innovation implemented in MSEs, especially in the context of public programs to foster innovation.

In addition, although there are several studies on innovation in micro and small companies, most adopt descriptive, qualitative or subjective perception-based approaches, without advancing in the objective measurement of the type of innovation implemented (Demircioglu & Audretsch, 2017; Kato-Vidal, 2019; Valladares et al., 2014). Previous research on the ALI Program, for example, has highlighted advances in innovative practices (Nogueira et al., 2017; Silva et al., 2018), but did not deepen the differentiation between incremental and radical innovations based on empirical and sectoral criteria. There are still few models that integrate consolidated diagnostic tools with quantitative metrics capable of guiding the strategic planning of MSEs according to their innovative maturity (Oliveira et al., 2014; Novais, 2024). In this sense, this work contributes by proposing a replicable and reasoned methodology that advances the understanding of the innovative behavior of these companies, filling a relevant gap in the national literature.

This study proposes a quantitative methodology to classify and analyze incremental and radical innovations in MSEs, based on the adaptation of the Sector Innovation Degree (GIS), originally developed by Oliveira et al. (2011). The approach was applied to 48 companies participating in the ALI Program (Local Innovation Agents), promoted by Sebrae-PE in 2022. The classification of innovations is based on the application of the Innovation Radar, a diagnostic tool that evaluates maturity in 18 topics related to management and innovation.

The main contribution of this study lies in the proposition and application of the Incremental Innovation Degree (G²I), a quantitative indicator derived from the Sectoral

Innovation Degree (GIS), adapted to the context of micro and small enterprises. This metric makes it possible to distinguish, on an empirical and sectoral basis, which innovative practices are considered incremental — widely disseminated and accessible — and which are configured as radical, as they require greater capacity for organizational or technological disruption. This is an important methodological advance compared to the more qualitative or generic approaches predominant in the literature.

In addition, G²I enables an individualized diagnosis of the innovative maturity of companies, functioning as an instrument to support strategic decision-making, both for MSE managers and for development agents and public policy makers. By integrating consolidated diagnostic tools (such as the ALI Radar) with an objective and scalable analytical logic, the study contributes to the construction of an operational framework that qualifies the process of prioritizing actions in environments with low installed capacity for innovation. This approach can be replicated in different sectoral and territorial contexts, expanding its potential for impact in the formulation of strategies aligned with the reality of Brazilian MSEs.

2 THEORETICAL FRAMEWORK

The advancement of discussions on innovation in MSEs demands an integrated theoretical approach, articulating different dimensions of innovation as a study phenomenon. In this context, this theoretical framework is structured in such a way as to contemplate three complementary axes. Initially, the relationship between innovation and productivity from the technological and managerial perspectives is discussed. Then, the distinction between incremental and radical innovations is deepened, highlighting their theoretical and operational implications. Finally, empirical studies related to the ALI Program, the database used, are presented, with the objective of positioning the present research within the scope of the existing literature and evidencing its contribution and limitations.

2.1 PRODUCTIVITY AND INNOVATION: MANAGERIAL AND TECHNOLOGICAL PERSPECTIVES

The relationship between innovation and productivity is one of the pillars of the economic and organizational literature, and is central to understanding the competitive performance of companies. This debate gains special relevance from Solow's Paradox, which evidences the apparent dissociation between technological advances and effective productivity gains, observed especially from the 1970s onwards in developed economies (TEIXEIRA, 2001).

In the context of this paradox, Macedo et al. (2024) argue that the gap between technological adoption and performance can be explained by the absence of organizational mechanisms capable of converting innovation into concrete results, especially in environments with structural constraints, as is the case of micro and small enterprises (MSEs). Empirical evidence from the study applied to the context of Pernambuco indicates that exogenous managerial innovation — such as that promoted by institutional programs — has a positive impact on the probability of productivity gains, significantly increasing the expected performance of these organizations.

This interpretation shifts the understanding of the paradox from a supposed limitation of technology to a problem related to the diffusion, assimilation, and complementarity between different types of innovation. Corroborating this perspective, recent studies show that innovations in products, processes, and technologies have a positive impact on the performance of firms, both in isolation and in an integrated way (MULOLLI et al., 2024). However, in the case of MSEs, this relationship takes on specific contours, since structural limitations, resource constraints, and organizational capacities condition the way innovations are incorporated and transformed into efficiency gains (GARRIDO-PRADA et al., 2024; ZHANG, 2025).

From this debate, the literature began to be structured in two main analytical approaches: macroeconomic and microeconomic (AUDRETSCH; BELITSKI, 2020). At the macroeconomic level, studies investigate the aggregate effects of innovation on the economic performance of countries, with an emphasis on technological diffusion and institutional capacity (GRIFFITH et al., 2006; DE NEGRI et al., 2021). On the other hand, the microeconomic approach focuses on the firm level, analyzing how organizational characteristics, business strategies, and internal capabilities influence productivity generation, both in developed and developing economies (MOHNEN et al., 2018; ROPER et al., 2017; NASSIF et al., 2017).

In general, these approaches converge in indicating that the simple adoption of technologies does not guarantee productivity gains, and that it is necessary to articulate them with innovations of a managerial nature. In this sense, recent literature emphasizes that productivity results from the interaction between technological innovation and organizational innovation, especially in contexts of resource constraints, as is the case of MSEs (ASAME et al., 2025). In addition, it is argued that saturation of incremental improvements can reduce the marginal impact of innovation on performance, reinforcing the importance of more disruptive strategies to sustain gains over time.

Thus, as argued by Macedo et al. (2024), overcoming the paradox depends on the integration between technological and managerial innovation, as well as on the ability of organizations to internalize and explore these complementarities. Although the literature recognizes the importance of innovation for productivity, this relationship is not homogeneous, varying according to the nature and intensity of the innovations implemented. In this sense, it is essential to distinguish different types of innovation, especially with regard to incremental and radical innovations, a topic that will be deepened in the next subsection.

2.2 INCREMENTAL AND RADICAL INNOVATION: CONCEPTS, DISTINCTIONS AND ANALYTICAL IMPLICATIONS

The distinction between incremental innovation and radical innovation is one of the central axes of the innovation management literature, allowing us to understand not only the degree of novelty of the changes implemented, but also their impacts on organizational performance. Since the classic studies of Dewar and Dutton (1986), this differentiation has been used to explain variations in the results of innovation, especially in terms of risk, complexity, and potential return.

Traditionally, this distinction has been strongly associated with the technological dimension, being defined from the level of disruption in products and processes (CHANDY; TELLIS, 1998; LENNERTS et al., 2020). However, more recent studies indicate that this classification is less objective than it seems, since different approaches use different criteria to characterize the degree of novelty, which generates conceptual ambiguities and difficulties in empirical measurement (KUSIAK, 2023; SI et al., 2022).

In this context, the Oslo Manual consolidates a multidimensional view of innovation, classifying it into four main categories: product, process, organizational, and marketing. This typology reinforces that innovation is not limited to the introduction of new technologies, but also involves transformations in the way organizations structure their activities, manage resources, and position themselves in the market.

Based on this expanded perspective, incremental innovation can be understood as the introduction of gradual improvements in products, processes or organizational practices, based on the recombination or adaptation of existing and widely disseminated knowledge in the sector. This type of innovation tends to present a lower degree of uncertainty and risk, being particularly relevant for companies with resource constraints, such as micro and small enterprises (MSEs), as it allows progressive gains in efficiency and competitiveness.

On the other hand, radical innovation refers to the introduction of substantial changes that imply a break with established practices, often associated with the incorporation of new knowledge, technologies or business models that are still not widespread in the market. These innovations have the potential to redefine technological and organizational trajectories, creating new frontiers of performance and competitive advantage (SHENG; CHIEN, 2016).

However, the distinction between incremental and radical innovation should not be understood as dichotomous, but rather as a continuum, in which different innovative practices can present varying degrees of novelty and impact. This perspective is particularly relevant in the context of MSEs, in which decisions related to innovation involve trade-offs between risk, cost and implementation capacity, and are often conditioned by structural limitations and low absorptive capacity.

In view of this, an important gap in the literature emerges: the difficulty of objectively operationalizing the distinction between incremental and radical innovation in empirical contexts. Several studies have sought to address this challenge through different measurement strategies. For example, classical approaches use the degree of perceived novelty in relation to the market or the firm as a classification criterion (DEWAR; DUTTON, 1986; CHANDY; TELLIS, 1998), while other studies adopt indicators based on technological intensity, investments in R&D or the introduction of new products (OECD, 2018; MOHNEN et al., 2018). There are also attempts at measurement based on surveys and managerial self-assessment, such as those derived from the use of the Innovation Radar and similar instruments applied in small companies.

However, these approaches have significant limitations. Perception-based measures tend to introduce subjective biases and difficulties in comparability between companies and sectors. Indicators based on R&D or technological intensity, in turn, are poorly suited for micro and small companies, which often innovate without formal structured investments. Survey-based instruments, on the other hand, face problems of standardization and methodological consistency, especially in heterogeneous contexts. As recent studies highlight, there is no consensus in the literature regarding the operational criteria that define the degree of novelty of an innovation, which compromises the comparability of empirical results (KUSIAK, 2023; SI et al., 2022; CROSSAN; APAYDIN, 2010).

In addition, contemporary systematic reviews point out that the absence of standardized metrics to classify innovations as incremental or radical constitutes one of the main limitations of the field, hindering both the replicability of studies and their practical application in public policies and business management (GARCÍA-SÁNCHEZ et al., 2024; DEMIRCloglu;

AUDRETSCH, 2017). This gap is even more critical in the context of MSEs, where innovation occurs in a diffuse, informal and strongly dependent way

It is in this context that the proposal of this study is inserted, by introducing the Degree of Incremental Innovation (G^2I) as a quantitative indicator capable of classifying innovative practices based on their sectoral diffusion. Considering that widely disseminated practices tend to reflect incremental innovations, while less widespread practices indicate a greater degree of novelty and disruptive potential, the proposed model allows for the operationalization, in an objective and comparable way, of the distinction between incremental and radical innovation. In this way, G^2I contributes to overcoming methodological limitations in the literature, offering an approach applicable to the context of MSEs and aligned with the need for empirical measurement of innovation.

2.3 EMPIRICAL STUDIES ON INNOVATION IN MSES AND THE ALI PROGRAM

The empirical literature on innovation in micro and small companies has been strengthened by studies applied to institutional development programs, such as the Local Innovation Agents Program (ALI), coordinated by Sebrae. In general, these surveys use diagnostic instruments, such as the Innovation Radar, to assess the innovative maturity of companies in different dimensions.

Studies carried out in different regional contexts show that the program contributes to the adoption of innovative practices and improvement of organizational performance (NOGUEIRA et al., 2017; VIRGENS et al., 2016; SILVA et al., 2018). However, most of these investigations adopt descriptive or qualitative approaches, focusing on the evolution of innovation indicators, without advancing in the distinction between different types of innovation implemented.

In this sense, there is a gap in the literature regarding the use of metrics capable of objectively classifying innovations in terms of their degree of novelty or rupture. The present study advances in this field by proposing the Incremental Innovation Degree (G^2I), allowing the differentiation of innovative practices based on their sectoral diffusion and contributing to a more accurate analysis of the nature of innovation in MSEs.

3 METHODOLOGY

This research adopts a quantitative, descriptive and analytical approach, with the objective of classifying and analyzing the nature of innovations implemented by micro and small enterprises (MSEs), distinguishing between incremental and radical practices based on a model based on empirical data.

3.1 POPULATION AND DATA SOURCE

The study population is composed of 48 micro and small companies participating in the 4th edition of the Local Innovation Agents Program (ALI), conducted by Sebrae-PE in 2022, in the Metropolitan Region of Recife. The companies are distributed in the sectors of commerce (22), industry (11) and services (15), reflecting the structural diversity of the universe of small businesses served by the program.

The data were obtained with authorization from the state coordination of the program, and came from the application of the diagnostic instrument called Innovation Radar. The ALI Program aims to stimulate innovation and increase productivity in small businesses through the performance of trained agents, who accompany companies throughout structured intervention cycles.

The Innovation Radar is the main methodological tool of the program, allowing the evaluation of the innovative maturity of companies in six dimensions: Management by Indicators, Sustainable Practices, Operations Management, Innovation, Marketing and Digital Transformation. Each dimension is subdivided into three themes, totaling 18 indicators evaluated, which enables a multidimensional analysis of innovation capacity.

3.2 DATA COLLECTION INSTRUMENT: THE ALI RADAR

Data collection was carried out through the application of the ALI Radar by trained local innovation agents, following a standardized protocol. For each of the 18 topics evaluated, a score was assigned based on an ordinal scale of five maturity levels, according to criteria established by Sebrae (2020).

This instrument allows measuring the company's stage of development in different dimensions of innovation, providing a structured and comparable basis for analysis. The standardization of the application process and the training of agents contribute to the consistency and reliability of the data collected.

3.3 CLASSIFICATION OF THEMES INTO TECHNOLOGICAL AND MANAGERIAL AXES

The 18 themes of the Innovation Radar were classified into two analytical axes: technological innovation and managerial innovation. This categorization was carried out based on the predominant nature of each theme, distinguishing practices related to the adoption of technologies and operational processes from those associated with management, organizational culture and decision-making.

This distinction allows analyzing not only the level of innovation of companies, but also the predominance of different types of innovation, contributing to the understanding of the relationship between technological innovation, managerial innovation and organizational performance.

3.4 CONSTRUCTION OF THE INCREMENTAL INNOVATION DEGREE (G^2I)

To assess the nature of the innovations implemented, this study adapts the Sector Innovation Degree (GIS) model, originally proposed by Oliveira et al. (2014), based on the innovation frontier logic inspired by Sawhney et al. (2006).

Consider a set of companies and dimensions (or themes) of innovation evaluated by the ALI Radar. Let the score assigned to the company in the dimension i , with $i = 1, \dots, n$ and $k = 1, \dots, K$, $D_{ik} \in [0, 5]$.

The company's Incremental Innovation Degree is defined as:

$$G^2I_i = \sum_{k=1}^K p_k D_{ik} \quad (1)$$

where p_k represents the weight associated with the dimension, subject to the restriction: $p_k \geq 0$ and $\sum_{k=1}^K p_k = 1$.

The weights are estimated from an optimization problem that seeks to maximize the average degree of incremental innovation in the set of companies, as follows:

$$\max_{p_k} \left(\frac{1}{n} \sum_{i=1}^n \sum_{k=1}^K p_k D_{ik} \right) \quad (2)$$

subject to: $\sum_{k=1}^K p_k = 1$ and $p_k \geq 0, \forall k$

This formulation implies that more widespread dimensions among companies — that is, those with a higher average contribution — tend to receive greater weight, being characterized as **incremental innovations**. On the other hand, dimensions that do not contribute to the maximization of the objective function (i.e., with $p_k = 0$) are interpreted as **radical innovations**, as they reflect practices that are not widely disseminated in the sector.

In addition, the Degree of Sectoral Incremental Innovation (G^2IS) is defined as:

$$G^2IS = \frac{1}{n} \sum_{i=1}^n G^2 I_i$$

This approach allows interpreting G^2I as a relative and endogenous measure of the structure of the sector analyzed, capturing the degree of diffusion of innovative practices and enabling the empirical distinction between incremental and radical innovation.

3.5 INTEGRATION WITH THE ALI PROGRAM AND DATA VALIDITY

The link to the ALI Program reinforces the robustness of the methodology adopted, since the Innovation Radar provides structured, comparable data directly associated with the interventions carried out in the companies. The actions developed by the agents aim to strengthen the absorptive capacity of entrepreneurs, according to the concept of Cohen and Levinthal (1990), expanding the ability of companies to recognize, assimilate and apply new knowledge.

In addition, the assisted application of the instrument, combined with the continuous monitoring of companies, contributes to the reduction of measurement biases and increases the reliability of the data. In this way, the institutional environment of the program acts as a methodological mediator, ensuring greater consistency in the collection and interpretation of information.

3.6 METHODOLOGICAL LIMITATIONS

Despite the consistency of the proposed model, some limitations must be considered. First, the sample is restricted to companies participating in the ALI Program in a specific region, which may limit the generalization of the results to other territorial or sectoral contexts.

In addition, the data used come from a diagnostic instrument applied by external agents, which, although standardized, may incorporate biases associated with the evaluators' interpretation and the degree of interaction with the entrepreneurs.

Another relevant point refers to the very nature of the G^2I model, which classifies innovations based on their relative diffusion in the analyzed set. Thus, the characterization of an innovation as incremental or radical depends on the empirical context considered, not being an absolute classification, but rather relational and dependent on the structure of the sector.

Finally, it is noteworthy that the model does not directly incorporate external variables, such as market conditions or financial performance, which opens space for future investigations that integrate G^2I into more comprehensive explanatory models.

4 RESULTS

The analysis of the data obtained from the application of the Innovation Radar allowed the identification of relevant patterns regarding the nature of innovations — technological and managerial — in micro and small companies in the Metropolitan Region of Recife. The results are presented from the logic of the Incremental Innovation Degree (G^2I), which allows empirically distinguishing incremental and radical practices based on their diffusion in the analyzed set.

4.1 CLASSIFICATION OF INNOVATION THEMES

Chart 1 presents the 18 themes evaluated, classified according to their nature (technological or managerial) and the type of innovation (incremental or radical), according to the weights estimated in the G^2I model.

In general, there is a relatively balanced distribution between incremental and radical innovations. However, the analysis of the data reveals that incremental innovations are associated with themes with higher average and lower dispersion, indicating wide diffusion among companies. Among these practices are management by indicators, monitoring, pricing, and customer satisfaction.

On the other hand, innovations classified as radical have lower averages and greater variability, showing that their adoption is not homogeneous and depends on specific capabilities of companies. Themes such as culture of innovation, product innovation, digitalization and digital presence stand out in this group, revealing relevant structural gaps in the innovative behavior of MSEs.

Table 1*Classification of sectors according to type of innovation*

		Inovação Gerencial ou Tecnológica?	Inovação Incremental ou de Ruptura?		
Dimensão	Temas		Comercio	Indústria	Serviço
Gestão por indicadores	Indicadores Chave	Gerencial	Incremental	Incremental	Incremental
	Estabelecimento de Metas	Gerencial	Incremental	Radical	Incremental
	Monitoramento	Gerencial	Incremental	Incremental	Incremental
Gestão das operações	Operação Enxuta	Tecnológica	Incremental	Incremental	Incremental
	Gestão por Processos	Tecnológica	Incremental	Incremental	Incremental
	Cultura de Alta Performance	Tecnológica	Radical	Incremental	Radical
Marketing	Satisfação do Cliente	Gerencial	Incremental	Incremental	Incremental
	Formação de Preços	Gerencial	Incremental	Incremental	Incremental
	Publicidade	Gerencial	Incremental	Radical	Incremental
Práticas sustentáveis	Gestão de Energia	Tecnológica	Radical	Radical	Radical
	Gestão de Água	Tecnológica	Radical	Radical	Radical
	Redução de Desperdício	Tecnológica	Incremental	Incremental	Incremental
Inovação	Inovação de Processos	Tecnológica	Incremental	Incremental	Incremental
	Inovação de Produtos e Serviços	Tecnológica	Radical	Radical	Radical
	Cultura da Inovação	Gerencial	Radical	Radical	Radical
Transformação digital	Digitalização Interna	Gerencial	Radical	Radical	Radical
	Presença Digital	Gerencial	Radical	Radical	Radical
	Meios Eletrônicos de Pagamentos	Gerencial	Radical	Radical	Radical

Source: Prepared by the authors.

This result reinforces the consistency of the G²I model by showing that sectoral diffusion is a valid empirical criterion to distinguish different types of innovation.

4.2 SECTORAL BEHAVIOR OF INNOVATIONS

The comparative analysis between the sectors of industry, services and commerce reveals relevant structural differences in the pattern of innovation.

In the industrial sector, greater heterogeneity is observed among the companies, with an arithmetic mean of 2.09 (SD = 0.53) and a weighted average of 2.85 (SD = 0.78). This pattern indicates the coexistence of companies with different levels of innovative maturity, suggesting that innovation relies heavily on internal and structural capabilities.

In the services sector, the results indicate greater homogeneity, with an arithmetic mean of 2.08 (SD = 0.31) and a weighted average of 2.26 (SD = 0.40). This behavior suggests a more uniform pattern of adoption of innovative practices, but with less intensity in the dimensions considered strategic.

The trade sector, on the other hand, has an arithmetic average of 2.14 (SD = 0.31) and a weighted average of 2.30 (SD = 0.35), showing an intermediate level, but with a higher concentration of companies at higher levels of innovation.

Table 2

Descriptive statistics of the sectors analyzed

Industry	Arithmetic Mean	DP	Weighted Average	DP	Average G ² I	DP
Industry	2,09	0,53	2,85	0,78	0,85	0,22
Services	2,08	0,31	2,26	0,40	0,89	0,23
Trade	2,14	0,31	2,30	0,35	0,97	0,22

Source: Prepared by the authors

Table 1 shows structural differences between the sectors, highlighting greater dispersion in industry and higher average level of innovation in trade.

In general, the results indicate that innovation does not occur homogeneously across sectors: while industry has greater dispersion and potential for radical innovation, trade shows greater diffusion of innovative practices, and services show intermediate and more homogeneous behavior.

4.3 FRONTIER OF INNOVATION AND TYPOLOGY OF RADICAL INNOVATIONS

The analysis of the mean scores and the dispersion of the themes classified as radical allowed us to identify three distinct patterns of innovative behavior:

- (i) Low medium and low dispersion. Topics such as energy management and water management have low levels of adoption and little variability between companies. This pattern indicates a relatively low innovation frontier, suggesting adoption opportunities with low risk and potential for immediate impact.
- (ii) Medium high. Topics related to digital transformation have high averages, indicating that its implementation requires deeper structural changes. In this case, radical innovation is associated with a higher degree of complexity and risk.
- (iii) Intermediate medium with high dispersion. Topics such as product innovation and innovation culture show high variability among companies, with some already operating at advanced levels. This pattern suggests an environment conducive to the

dissemination of knowledge among peers, with potential for learning and replication of good practices.

4.4 DEGREE OF INCREMENTAL INNOVATION (G^2I) OF COMPANIES

Table 3 presents the G^2I values for the companies analyzed, allowing the level of innovative maturity to be evaluated individually.

Table 3

Degree of Incremental Innovation (G^2I) of companies by sector

Company	Commerce	Industry	Service	Company	Commerce	Service
Company 01	1,1	1,1	1,1	Company 12	1,1	1,1
Company 02	0,7	0,7	0,7	Enterprise 13	1,1	1,1
Company 03	0,8	0,8	0,8	Company 14	0,7	0,7
Company 04	0,9	0,9	0,9	Company 15	1,2	1,2
Company 05	0,6	0,6	0,6	Company 16	1,2	
Company 06	0,6	0,6	0,6	Company 17	1,2	
Company 07	0,6	0,6	0,6	Enterprise 18	1,2	
Company 08	0,8	0,8	0,8	Company 19	1,2	
Company 09	1,1	1,1	1,1	Enterprise 20	1,1	
Enterprise 10	0,9	0,9	0,9	Enterprise 21	1,1	
Enterprise 11	1,2	1,2	1,2	Enterprise 22	0,9	

Source: Prepared by the authors based on the calculation of G^2I

Based on the results, it is observed that there are three distinct profiles of companies:

Low G^2I (≤ 0.7): companies with low innovative maturity, for which prioritizing incremental innovations is more appropriate, due to lower risk and greater ease of implementation.

Intermediate G^2I (0.8 – 1.0): companies in transition, with the potential to gradually move towards more sophisticated practices.

High G^2I (≥ 1.1): companies with greater innovative capacity, able to implement radical innovations and explore opportunities for greater competitive impact.

This segmentation reinforces the applied character of the G^2I model, allowing differentiated innovation strategies to be guided according to the stage of maturity of the companies.

The analysis of specific cases reinforces the practical applicability of the model. Companies with high G^2I have a greater capacity to incorporate more sophisticated managerial and technological practices, while companies with low G^2I tend to focus efforts on incremental improvements of less complexity.

These results show that G^2I can be used as an instrument to support decision making, allowing to guide innovation strategies according to the stage of maturity of the companies.

5 DISCUSSION

The results obtained in this study allow us to advance in the understanding of the nature of innovation in micro and small enterprises (MSEs), especially by integrating empirical evidence with the theoretical debate on incremental and radical innovation. In general, the findings reinforce the idea that innovation in MSEs occurs in a heterogeneous way, being strongly conditioned by structural, organizational and sectoral factors.

First, the identification that incremental innovations are concentrated in widely disseminated managerial and operational practices — such as monitoring, process management, and pricing — corroborates the literature that highlights the role of incremental innovation as the main mechanism of adaptation in resource-constrained environments. This result is consistent with studies indicating that MSEs tend to prioritize low-risk continuous improvements, to the detriment of more disruptive innovations.

On the other hand, the finding that dimensions associated with technological and strategic innovation — such as digitalization, culture of innovation and development of new products — remain not widespread highlights the existence of a structural gap in the innovative behavior of these companies. This finding dialogues directly with the literature on limitations of absorptive capacity in MSEs, suggesting that the difficulty is not in the availability of innovative solutions, but in the ability to assimilate and implement these practices.

In this sense, the results contribute to reinterpret Solow's Paradox in the context of MSEs. Rather than indicating an inefficiency of the technology, the data suggest that the limitation lies in the low diffusion and complementarity between technological and managerial innovation. Thus, the absence of significant productivity gains can be explained by the predominance of incremental innovations and the low incorporation of more disruptive practices.

The comparative analysis between sectors reinforces this interpretation. The industry showed greater dispersion in the indicators, evidencing the coexistence of companies at different stages of innovative maturity, which suggests greater potential for radical innovation, albeit unevenly. On the other hand, the services and trade sectors showed greater homogeneity, with emphasis on trade, which had a higher average of G²I, indicating a greater diffusion of innovative practices.

This industry pattern suggests that innovation in MSEs is not only a function of the internal capabilities of companies, but also of the competitive environment and characteristics of the sector in which they operate. While more structured sectors can favor the emergence of more complex innovations, more dynamic and market-oriented sectors tend to stimulate the diffusion of incremental practices.

Additionally, the typology proposed from the analysis of the mean and dispersion of the themes contributes to the conceptual advancement of the literature by demonstrating that radical innovation is not a homogeneous phenomenon, but presents different patterns of diffusion and complexity. The identification of topics with high dispersion indicates the existence of "islands of excellence", in which some companies already operate at advanced levels of innovation, creating opportunities for learning and dissemination for the rest of the sector.

Finally, the results show the robustness of the G²I model as an analytical instrument. By classifying innovations based on their sectoral diffusion, the model overcomes limitations of subjective approaches or those based exclusively on technological intensity, offering an objective and contextualized metric. This characteristic expands its applicability both for academic purposes and for practical use in innovation support programs.

6 CONCLUSION

This study aimed to analyze the nature of innovations in micro and small companies, distinguishing between incremental and radical practices from a quantitative approach based on the Incremental Innovation Degree (G²I). From the application of the model to companies participating in the ALI Program in Pernambuco, it was possible to advance in the empirical measurement of innovation, contributing to overcome a relevant gap in the literature.

The results show that innovation in MSEs is predominantly incremental, concentrating on widely disseminated managerial and operational practices. On the other hand, radical innovations, associated with technological and strategic transformations, have a lower level of diffusion, indicating a potential that is still little explored.

The sectoral analysis revealed that innovative behavior varies significantly between industry, services and commerce. While industry presents greater heterogeneity and potential for radical innovation, trade demonstrates greater diffusion of innovative practices, and services present an intermediate and more homogeneous pattern. These results reinforce the importance of considering the sectoral context in the formulation of innovation strategies.

From a theoretical point of view, the study contributes by proposing and validating the G²I model as a tool capable of operationalizing the distinction between incremental and radical innovation in an objective and data-based way. By using sectoral diffusion as a classification criterion, the model offers an alternative to traditional approaches, often limited by subjectivity or inadequacy to the context of MSEs.

In practical terms, the results indicate that innovation strategies must be aligned with the maturity level of companies. For organizations with low G²I, it is recommended to prioritize

incremental innovations, with a focus on operational and managerial improvements. Companies with greater maturity, on the other hand, can move on to more complex innovations, exploring opportunities for differentiation and competitive advantage.

In addition, the findings suggest that public policies and development programs, such as the ALI, should act not only in the promotion of innovation, but also in the expansion of the absorptive capacity of companies, favoring the diffusion and internalization of more advanced practices.

Finally, limitations related to the scope of the sample and the relational nature of the model are recognized, which opens space for future research. Further studies can explore the application of G²I in different regional and sectoral contexts, as well as its integration with economic performance indicators, expanding the understanding of the relationship between innovation and productivity.

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PALATAL MEMORY PLATE IN TRISSOMY 21: BENEFITS OF EARLY INTERVENTION IN OROFACIAL DEVELOPMENT

PLACA PALATINA DE MEMÓRIA NA TRISSOMIA 21: BENEFÍCIOS DA INTERVENÇÃO PRECOCE NO DESENVOLVIMENTO OROFACIAL

PLACA DE MEMORIA PALATINA EN LA TRISOMÍA 21: BENEFICIOS DE LA INTERVENCIÓN TEMPRANA EN EL DESARROLLO OROFACIAL



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ABSTRACT

The Palatal Memory Plate (PMP) is a transdisciplinary therapeutic resource aimed at early intervention in infants with Trisomy 21 (T21) and in cases of marked orofacial hypotonia. Indicated from two months of age, the PMP promotes the balance of the stomatognathic system, favoring vital functions such as nasal breathing, sucking, swallowing, chewing, and phonation, positively impacting the individual's overall development. Children with T21 frequently present orofacial characteristics such as hypoplasia of the midface, relative pseudomacroglossia, delayed tooth eruption, malocclusions, and labial and lingual hypotonia, which can compromise breastfeeding, swallowing, breathing, and sleep. Early intervention with PPM (Positive Myofunctional Therapy), combined with myofunctional therapy, acts on the postural reorganization of the tongue and lips, stimulates lip seal, automates nasal breathing, and strengthens the orofacial musculature, promoting harmonious development of the face and stomatognathic functions. Ten infants with Down syndrome (T21) were evaluated, and this study demonstrates that the application of PPM, accompanied by speech therapy and pediatric dentistry guidance, resulted in significant improvement in the habitual posture of the tongue and lips, muscle adaptation, and feeding functions. The effectiveness of PPM depends on adequate supervision and multidisciplinary integration, representing an effective therapy when the intervention is early, contributing to the reorganization of the orofacial musculature, prevention of future alterations and malocclusions, and improvement in the quality of life of people with T21.

Keywords: Down Syndrome. Orofacial Hypotonia. Myofunctional Therapy. Stomatognathic System.

RESUMO

A Placa Palatina de Memória (PPM) constitui um recurso terapêutico transdisciplinar voltado à intervenção precoce em bebês com Trissomia do Cromossomo 21 (T21) e em casos de hipotonicidade orofacial acentuada. Indicada a partir de dois meses de idade, a PPM promove o equilíbrio do sistema estomatoglossognático, favorecendo funções vitais como respiração nasal, sucção, deglutição, mastigação e fonação, impactando positivamente no

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desenvolvimento global do indivíduo. Crianças com T21 frequentemente apresentam características orofaciais como hipoplasia do terço médio da face, pseudomacroglossia relativa, atraso na erupção dentária, maloclusões e hipotonia labial e lingual, que podem comprometer a sucção do leite materno, a deglutição, a respiração e o sono. A intervenção precoce com PPM, aliada à terapia miofuncional, atua na reorganização postural da língua e dos lábios, estimula o selamento labial, automatiza a respiração nasal e fortalece a musculatura orofacial, promovendo desenvolvimento harmônico da face e das funções estomatoglossognáticas. Foram avaliados dez bebês com T21 e demonstra-se aqui que a aplicação da PPM, acompanhada de orientação fonoaudiológica e odontopediátrica, resultou em melhora expressiva na postura habitual da língua e dos lábios, adaptação muscular e funções alimentares. A eficácia da PPM depende de supervisão adequada e integração multidisciplinar, representando uma terapia eficaz quando a intervenção é precoce, contribuindo para a reorganização da musculatura orofacial, prevenção de alterações e maloclusões futuras e melhoria da qualidade de vida de pessoas com T21.

Palavras-chave: Síndrome de Down. Hipotonia Orofacial. Terapia Miofuncional. Sistema Estomatoglossognático.

RESUMEN

La Placa de Memoria Palatina (PMP) es un recurso terapéutico transdisciplinario dirigido a la intervención temprana en lactantes con trisomía 21 (T21) y en casos de hipotonía orofacial marcada. Indicada a partir de los dos meses de edad, la PMP promueve el equilibrio del sistema estomatognático, favoreciendo funciones vitales como la respiración nasal, la succión, la deglución, la masticación y la fonación, impactando positivamente en el desarrollo general del individuo. Los niños con T21 frecuentemente presentan características orofaciales como hipoplasia del tercio medio facial, pseudomacroglosia relativa, erupción dental tardía, maloclusiones e hipotonía labial y lingual, que pueden comprometer la lactancia materna, la deglución, la respiración y el sueño. La intervención temprana con PPM (Terapia Miofuncional Positiva), combinada con terapia miofuncional, actúa sobre la reorganización postural de la lengua y los labios, estimula el sellado labial, automatiza la respiración nasal y fortalece la musculatura orofacial, promoviendo un desarrollo armónico de la cara y las funciones estomatognáticas. Se evaluaron diez lactantes con síndrome de Down (T21), y este estudio demuestra que la aplicación de la terapia miofuncional orofacial (TMO), acompañada de terapia del habla y orientación odontológica pediátrica, resultó en una mejora significativa de la postura habitual de la lengua y los labios, la adaptación muscular y las funciones de alimentación. La eficacia de la TMO depende de una supervisión adecuada y una integración multidisciplinaria, lo que la convierte en una terapia eficaz cuando la intervención es temprana, contribuyendo a la reorganización de la musculatura orofacial, la prevención de futuras alteraciones y maloclusiones, y la mejora de la calidad de vida de las personas con T21.

Palabras clave: Síndrome de Down. Hipotonía Orofacial. Terapia Miofuncional. Sistema Estomatognático.

1 INTRODUCTION

The memory palatal plate (MPP) represents a transdisciplinary therapeutic resource of early intervention for use in infants with Trisomy 21 (T21), formerly known as Down Syndrome, as well as in cases of marked hypotonocicity of the orofacial muscles, many of which are idiopathic. Such an opportunity for intervention, very early, occurs from two months of life, takes the focus off the teeth and mouth and broadens the vision of the professionals involved, namely pediatric dentist and speech therapist, in the search for the balance of basic and vital functions, rebalancing the entire stomatoglossognathic system. As such, the focus should be on the potentialities and interventions made to contribute to the child's development and not on the limitations that Trisomy 21 and other disabilities often represent in an initial contact.

Trisomy 21 is not a disease, but a genetic condition, with its nomenclature associated with the presence of 1 more chromosome in pair 21. It is currently referred to as T21, a term used here.

The gold standard for the diagnosis of Trisomy 21 is to perform the karyotype with an extra copy of the long arm of chromosome 21 (Lejeune et al., 1959), naturally it is the most common human aneuploidy among live births. However, it can be diagnosed clinically based on the characteristic appearance (facial gestalt) and behavior of affected individuals Radhakrishnan et al. (2018). The facial gestalt characteristic of Trisomy 21 is an important clinical tool for syndromic recognition, especially in the first moments of neonatal and pediatric evaluation. This concept refers to the global set of observable phenotypic characteristics, especially craniofacial, which, when analyzed together, allow for a strong diagnostic suspicion. Among the most frequently described findings are a flat face, flattened nasal bridge, superior oblique palpebral fissures, small ears, and relative protrusion of the tongue. As described by Radhakrishnan et al. (2018), facial gestalt represents an essential resource in the clinical identification of Trisomy 21, aiding diagnosis and early indication for cytogenetic confirmation, whose blood collection must occur even before leaving the maternity hospital, as ensured by law (Municipal Law 13.548/2017), in force in João Pessoa, Paraíba, Northeast Brazil.

Among the typical characteristics in neonates with Trisomy 21 are hypotonia and hyperextension, associated with a smaller maxilla, due to hypoplasia of the middle third of the face (Ferreira et al., 2023) and this affects breathing, speech, dental arch, and auditory processing (Abbeduto et al., 2015). This often causes difficulty in sucking and swallowing breast milk and the consequent search for adequate guidance to prioritize breastfeeding (Dantas et al., 2022).

There is also a compromise in the quality of sleep of people with T21, hence the need for early intervention in the baby (Guilleminaut; Eldridge; 1976; Gonçalves et al., 2011; Jayaratne et al., 2017). Sleep disturbances in individuals with Trisomy 21 have been associated with differences in facial morphology assessed in 3D and specific changes reported include adenotonsillar hyperplasia, mesofacial and mandibular hypoplasia, hypotonia, macroglossia, choanal atresia, an acute angle of the cranial base, and small upper airways (Jayaratne et al., 2017). Fernandez et al. (2017) describe that overall sleep quality was poor and efficiency scores were lower in infants with Trisomy 21 than in children with neurotypical development. Infants with Trisomy 21 exhibited greater sleep fragmentation, although sleep efficiency and consolidation increased with age, the authors highlight a high prevalence of sleep apnea, up to 50% in preschool-aged children with T21 (Fernandez et al., 2017). Thus, the importance of balance and muscle tone for the quality of life of individuals with T21 is clear and evident. This ensures them a better development and execution of basic functions such as breathing, sucking, swallowing and, subsequently, chewing and articulating a comprehensive oral expression.

In T21, some oral characteristics are found and can be observed very early (Table 1). They are:

Late tooth eruption, which favors the use of the memory palatal plate, as the late and asynchronous dentition will be complete around 4 to 5 years.

Babies have midface hypoplasia, that is, a smaller maxilla due to the middle third of the face being reduced. The skull is slightly microcephalic and brachycephalic with a flat occipital. The fontanelles tend to be large, a third fontanelle may be palpable, and close late. The face is round in the newborn and in the nursing mother. Usually the nostrils are small, the mouth is facing downwards and a small oral cavity generates a tendency to protrude the tongue and breathe through the mouth. The growth of the jaw tends to overtake the palate leading to prognathism.

Tooth wear is twice as common in T21 when compared to the neurotypical population, which is supported by a high rate of bruxism and has repercussions on the increase in cases of gastric reflux. Pseudomacroglossia refers to the condition in which the tongue is normal in size, but appears to be enlarged due to anatomical or functional factors of the oral environment, such as reduction of the intraoral space, resulting from narrow dental arches, mandibular retrognathism, or hypertrophy of adjacent structures (Proffit; Fields; Sarver, 2013). It is a relative macroglossia and a greater hypotonicity of the muscles of the oropharynx, which, as well as

excessive salivation and a shortened and thick lingual frenulum, represent factors that contribute to the difficulties in feeding, breathing, swallowing and speaking.

Table 1

Oral characteristics found in T21

Delay in tooth eruption
High susceptibility to periodontal disease
Excessive salivation
Conoid teeth
Aresic jaw
Dental Agenesis
Malocclusions
Mouth breathing
Shortened and thick lingual frenulum
Impaired sleep quality

Source: Authors.

The memory palatal plate is a great ally in this initial development process of people with Trisomy 21, because through this therapeutic resource, an early intervention correctly organizes and stimulates stomatoglossognathic functions. As demonstrated, the partnership between speech therapist and pediatric dentist is essential.

All these characteristics are common in T21, but we also notice them in typical children, not making it impossible for them to be treated in the same way.

Within the scientific community there is a consensus that we cannot assign degrees to Trisomy 21 (Down Syndrome), that is, there are no degrees, although each child expresses the genes in a specific way. Some with more pronounced hypotonia on the face, others not, so the attentive and personalized look must exist.

The etiology of the characteristic appearance and associated specific features of Trisomy 21 are presumed to be related to the effects of dosing chromosome 21 genes, but epigenetic effects may also contribute.

The guiding principle when it comes to development is called stimulus. Early and correct stimulation during the first year of life, a period of greater development of the central nervous system and the baby's oral cavity, makes all the difference for a good global development of the individual, whether with T21 or a typical person. Therefore, the Memory Palatal Plate is an option that allows for early stimuli.

From birth, nasal breathing is a vital situation for human beings. This is physiological respiration, which favors the growth and good anatomical and functional development of the

most diverse structures of the body. It directly influences the maintenance of skeletal, dental and muscular organization of the stomatoglossognathic system, orofacial functions, as well as physical and intellectual development. When this breathing starts to occur orally, it forces the stomatoglossognathic system to promote structural changes in its functionality. This endangers the existing balance between masticatory functions, the position of the tongue at rest, swallowing, breathing and phonation, conditions that contribute to good development and orofacial growth. The muscles of the face must work in a balanced way so that the growth and development of the bones of the face happen in a correct and symmetrical way (Carvalho, 2010).

The child, when breathing through the mouth, needs to adapt the posture of the head to be able to breathe better, forwarding it so that the air reaches the lungs more quickly, flexing the neck forward, rectifying the path of the airways. This movement causes changes in the posture of the mandible, the hyoid bone and the tongue, bringing consequences for facial growth and occlusion, interfering with eating functions (sucking, chewing and swallowing). Therefore, some interventions can start in babies as young as 2 months old.

2 PRESENTATION OF CLINICAL CASES

The research participants consisted of ten children diagnosed with T21, aged between 02 and 24 months. None of them had other associated syndromes, craniofacial malformations, cardiac or respiratory disorders. These participants were recruited from among those treated at the clinic where the study was conducted. Because the children were diagnosed with T21, they were evaluated by a pediatric dentist and a speech therapist at the first meeting. The myofunctional and orofacial evaluation included the verification of tone, habitual posture of lips and tongue, lingual frenulum, as well as anamnesis to investigate the food provided by the caregiver and the presence of oral habits.

All of them had decreased lips and tongue tone and altered habitual posture, with increased salivation and unaltered frenulum of the tongue. Then, after explaining to the family about the proposed therapy, the speech therapist proceeded with the desensitization to the mold and subsequent use of the PPM, with the number of sessions appropriate to each case, and the pediatric dentist made the mold of the upper arch of each participant to make the PPM, which was delivered the following week. to those responsible for the child. The PPMs used can be seen in Figure 1. From then on, the participants received the PPM and the parents were instructed to insert it into the child's oral cavity at least four times a day, with a minimum period of 30 supervised minutes. They were also instructed to increase the use according to the

evolution of the child's adaptation and comfort. Those responsible were also instructed on the hygiene of the plate and not to use it during feeding, nor during sleep or away from an adult's observation.

3 RESULTS AND DISCUSSION

The memory palatal plate (Figure 1) is defined as a removable intraoral device, made of acrylic, initially designed by Castillo-Morales (1991), with the objective of assisting the correct positioning of the tongue and stimulating lip sealing, encouraging nasal breathing. It is indicated for babies with lip hypotonia, absence of lip sealing, and tongue protrusion, contributing to myofunctional balance, nasal breathing, and the harmonious growth and development of facial bones and muscles (Furlan et al., 2022; Carvalho et al., 2025).

The memory palate plate is a great ally in this initial development process of people with Trisomy 21, because through this therapeutic resource, it is possible to correctly organize and stimulate the stomatoglossognathic functions in the baby at an early age. As demonstrated, the partnership between speech therapist and pediatric dentist is essential.

Figure 1

Palatal memory plates with expander screw used in the study



Source: Dalapicola, K.

The alterations mentioned above (Table 1) favor the malfunction of the stomatoglossognathic system, because for the functions of this system to be carried out effectively, it is necessary that the responsible structures work in harmony, which will favor its development, using a minimum expenditure of energy by the child (Medeiros, 2016). However, when any constituent of this system operates inadequately, imbalances may occur that have

repercussions on the other stomatognathic functions, compromising the functional harmony of the system (Marchesan; Krakauer, 2011).

In clinical practice, there is a prevalence of teeth with morphological anomalies, the most common being the conoid shape, characterized by being narrow and tapered. Dental crowns are smaller and shorter, and this can contribute to the instability and susceptibility to tooth loss associated with periodontal disease. In addition, there is atresia in the maxilla and deep palate, which require attention in the exercises instructed by the speech therapist. The occurrence of agenesis or supernumerary dentition also shows a higher than expected record in the population with T21 when compared to neurotypical children.

Among the consequences, mouth breathing, snoring, and respiratory apneas during sleep stand out. In turn, the high incidence of periodontal disease may be due to hypotonia, laxity of the dentoalveolar joint, poor dental hygiene, and immune system deficiencies.

Regarding malocclusions, the most common in this study was anterior crossbite, due to the tongue resting on the oral floor. Occlusal problems, most often in the central, lateral, and canine incisors, are common and result from mouth breathing, chewing difficulty, dental agenesis, shortening and asymmetry of the upper arch, and temporomandibular problems.

After a combination of techniques, Dr. Fabiane Bittar (CFO, 2023) innovated by adding the expander screw, used in functional jaw orthopedics appliances and developed the memory palate plate used here, whose mold is made with dental molding material, addition silicone, heavy paste and catalyst in personalized acrylic trays

A first and important step in conducting the process of using PPM is the desensitization of the baby's oral cavity for molding and use of the plate itself. In this process, the speech therapist and the pediatric dentist work together (Figure 2a-c). After the initial intervention, periodic follow-up is followed so that the determined objectives are achieved and the plate is adjusted and even discontinued when the goal defined in that baby is met (Figure 3a-c).

Figure 2

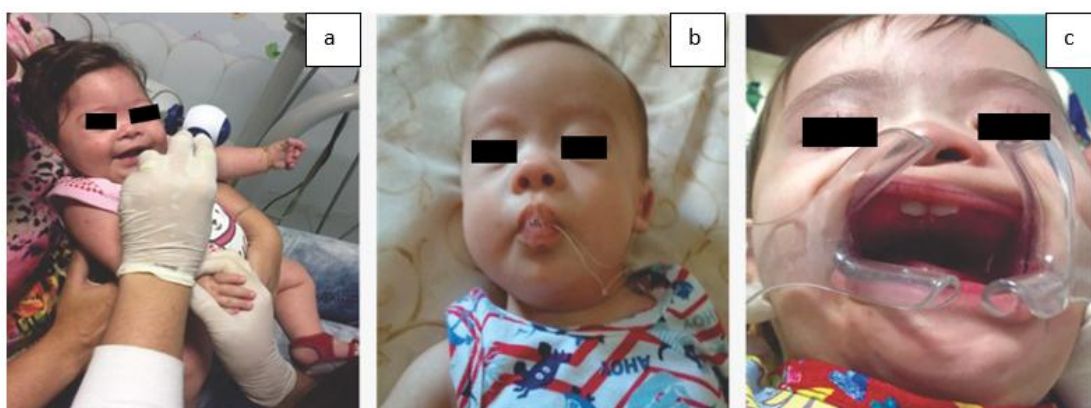
Interventions with speech therapy to desensitize the oral cavity of the infant with T21, to receive the memory palatal plate



Source: Dalapicola, K.

Figure 3

a) Speech therapy with extraoral stimuli; b) Baby with T21 with the plate in the mouth showing adaptation and acceptance; c) Palatal plaque being relieved in the region of 51 and 61 so as not to prevent the eruption of the teeth



Source: Dalapicola, K.

The sooner the treatment begins, the greater the baby's acceptance, the better the muscle memory and its conditioning to use; therefore, PPM is indicated from 2 months of age.

The use of the plate seeks to minimize the existing orofacial changes, correcting the tongue posture from an early age, working on lip sealing with the objective of returning nasal breathing, training the muscles of the face, developing swallowing, chewing and later speech. This was evidenced as soon as the children with T21 used the plate for the first time (Figure 4).

Technological advances in the health area have enabled the development of increasingly aesthetic and minimally invasive therapeutic approaches. In this context, the importance of integrating functionality and aesthetics is emphasized, as long as such association does not imply risks or discomfort to the patient. Thus, the elaboration of the therapeutic plan should consider the particularities of the family routine, including aspects such as the responsible caregiver, adherence to the use of the device, time of use and availability for clinical follow-up. Such factors are determinant for the effectiveness of treatment, especially in interventions that require continuous use of intraoral devices, such as PPM (CFO, 2023 p. 28).

Figure 4

Before and after: evidence of immediate lip sealing after use of the memory palate plate in children with T21



Source: Dalapicola, K.

It has been confirmed that hypotonia of the orofacial muscles is evident in Trisomy 21, since there is a global hypotonia (Mustacchi; Rozoni, 1990), which can limit basic and vital functions such as breathing, sucking and swallowing. Later, it can compromise chewing and speech. Dentistry can be a great ally, enabling early intervention through these therapeutic resources. Evaluating the applicability of PPM as early as possible was also recorded by Ferreira et al. (2023) in babies with Trisomy 21, the authors concluded that the Memory Palatal Plaque associated with myofunctional therapy was more effective when started early, between 1 and 2 months of age, with records of advances in the usual posture of the tongue and lips, especially in patients who had more altered postural conditions in the initial evaluation.

Decreased tone in the perioral muscles, lips, and masticatory muscles, as well as decreased tongue movements, can lead to sucking difficulties in infants with Trisomy 21. They tend to breastfeed for less time, have more respiratory infections, and develop non-nutritive sucking habits, such as increased dependence on bottle-feeding, finger sucking, and pacifier use (Abbeduto et al., 2015). Understanding the specificities in the development of Trisomy 21 represents a look at the most diverse fronts of action and should encompass all children, not only those with T21.

4 CONCLUSION

In view of the above, it is concluded that the use of PPM brings clear benefits to babies with T21, such as stimulating the tongue to be in the correct position, that is, on the palate, adequate stimulation for better lip sealing, automating nasal breathing, improving maxillary development and avoiding mandibular protrusion. Emphasizing that PPM is an auxiliary means of treatment, its use alone, in isolation, does not imply satisfactory results in the face of the challenges of global hypotonia, innate at T21.

Treatment with the memory palatal plate ideally begins with the baby at two months of age and monthly follow-up in general for a period of one year to a year and a half, depending on the tooth eruption and evaluating the improvement in the functions of the orofacial muscles.

The control of the plate must be done by competent and properly trained professionals. The use of the splint without the respective orofacial treatment with a multidisciplinary team is considered, totally meaningless. Performed early, treatment can avoid more invasive interventions and severe malocclusions in the future.

Early intervention and finely tuned partnership between pediatric dentist and speech therapist achieve very satisfactory results in the orofacial development of children with T21, as they allow significant improvement in hypotonia, re-educating and strengthening the oral

muscles, correcting tongue protrusion, normalizing and returning nasal breathing, factors that reflect an improvement in the quality of life of these patients.

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ACCESS TO DRINKING WATER IN THE AMAZON REGION OF PARÁ: A COMPARATIVE ASSESSMENT BETWEEN THE STATE OF PARÁ AND THE MUNICIPALITY OF PARAGOMINAS-PA BASED ON QUALITY AND AVAILABILITY INDICATORS

ACESSO A ÁGUA POTÁVEL NA AMAZÔNIA PARAENSE: AVALIAÇÃO COMPARATIVA ENTRE O ESTADO DO PARÁ E O MUNICÍPIO DE PARAGOMINAS-PA COM BASE EM INDICADORES DE QUALIDADE E DISPONIBILIDADE

ACCESO AL AGUA POTABLE EN LA REGIÓN AMAZÓNICA DE PARÁ: UNA EVALUACIÓN COMPARATIVA ENTRE EL ESTADO DE PARÁ Y EL MUNICIPIO DE PARAGOMINAS-PA BASADA EN INDICADORES DE CALIDAD Y DISPONIBILIDAD



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ABSTRACT

Access to potable water in Brazil is significantly unequal, a reality that intensifies in the state of Pará, located in the Amazon region of Pará. This study aims to quantitatively analyze water accessibility in the state, with an emphasis on comparing the municipality of Paragominas-PA with other municipalities in Pará. The methodology was based on the analysis of secondary data from the National Sanitation Information System (SNIS), the National Basic Sanitation Survey (IBGE), and reports from the National Water Agency (ANA), in addition to the application of perception questionnaires to 40 participants from the municipality of Paragominas. The results show that, although the overall coverage rate is low, Paragominas stands out with a high percentage of service (95.75%), similar to the capital Belém. User perception indicated a high level of satisfaction (ISA = 1.00), but low confidence in direct water consumption (ICC = 0.3), revealing a contradiction between the regularity of supply and confidence in direct consumption. It is concluded that, despite some progress, significant social inequalities related to service reliability persist, requiring integrated public policies,

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structural investments, and communication strategies to strengthen public trust. Thus, this study contributes to the water supply in Pará, ensuring the human right to access water.

Objective: The objective of this study is to analyze access to potable water in the state of Pará, based on data from official sources, by comparing water supply indicators in the municipality of Paragominas-PA, the capital city of Belém, and other municipalities in Pará, aiming to assess the percentage of the population served and identify challenges and possibilities for expanding access to treated and safe water.

Theoretical Framework: Access to treated water and basic sanitation was recognized in 2010 by the United Nations (UN) as a fundamental human right, indispensable to guaranteeing the dignity, health, and well-being of the population. This recognition represents a significant normative milestone, guiding the formulation of public policies aimed at reducing inequalities in access to water supply and basic sanitation services. Within this context, the role of the Sustainable Development Goals (SDGs) stands out, especially SDG 6, which establishes as a goal ensuring the availability and sustainable management of water and sanitation for all. This guideline reinforces the importance of studies that analyze the conditions of access to drinking water, especially in the Amazon region, which is still marked by social inequalities. The unequal distribution of social services remains a major difficulty. Equity in access is a condition for the well-being of the population. At this point, it is possible to assess the importance of water governance, playing a significant role in Brazil and in the State of Pará, in a way that can guide the organization of supply systems and the formulation of new public policies focused on water resources, so that social justice can begin to bear fruit related to equal access. Currently, water resource governance in Pará relies on the National Basic Sanitation Policy (Law 11.445/2007); the National Water and Basic Sanitation Agency (ANA); the State Secretariat for the Environment (SEMAS-PA); the State Water Resources Commission; the Basin Committee; and the Pará Sanitation Company (COSANPA). Therefore, this study is of paramount importance for contributing to public policies, with improvements focused on access to water and water governance in the state as a whole. It is also an important topic to be discussed in the academic world.

Method: This study is characterized as a mixed-methods research (quantitative and qualitative), with exploratory and descriptive objectives, focused on access to drinking water in the state of Pará. The quantitative phase was based on the collection and analysis of secondary data from official databases, including the National Sanitation Information System (SNIS), the National Basic Sanitation Survey (PNSB), conducted by the Brazilian Institute of Geography and Statistics (IBGE), and reports from the National Water and Basic Sanitation Agency (ANA). Additionally, a documentary analysis of Ordinance GM/MS No. 888/2021, which establishes the potability standards for drinking water in Brazil, was carried out to support the discussion on the quality and safety of distributed water. The qualitative phase consisted of conducting field research in the municipality of Paragominas-PA, through the application of a structured questionnaire to the local population. The sample consisted of 40 participants selected by convenience in a public place with high traffic. The instrument included questions related to the perception of water quality, regularity of supply, and level of satisfaction with the services provided. Quantitative data were analyzed using descriptive statistics, with calculation of frequencies and percentages, allowing for comparison between the evaluated indicators. For the analysis of qualitative data, a descriptive approach was adopted, seeking to identify patterns of user perception. In addition, two synthetic indicators were developed: the Supply Satisfaction Index (ISA) and the Consumption Confidence Index (ICC), with the objective of measuring, respectively, the level of user satisfaction with the service provided and confidence in the direct consumption of water. These indicators range from 0 to 1, with values closer to 1 indicating better evaluation conditions.

Results and Discussion: The results obtained show a predominantly positive perception on the part of the participants regarding the quality and

distribution of water supplied in the municipality of Paragominas-PA. Most respondents expressed satisfaction with the services provided by the municipal authority, indicating that the water supply has generally met basic demands. Research Implications: The research presents relevant implications for basic sanitation and water resource management by highlighting inequalities in access to drinking water in the state of Pará. The results indicate the need to improve public policies, both in terms of expanding coverage and strengthening public confidence in the quality of the distributed water. The proposed indicators, such as the Water Supply Satisfaction Index (ISA) and the Consumption Confidence Index (ICC), prove to be useful tools for monitoring and decision-making, contributing to more efficient and appropriate strategies for the local reality. Originality/Value: The study contributes to the literature by offering an updated quantitative analysis of accessibility to treated water in the State of Pará through official data and theoretical references on the human right to water, social justice, and water governance.

Keywords: Accessibility. Treated Water. Human Rights. Water Resources.

RESUMO

O acesso a água potável no Brasil possui uma desigualdade significativa, realidade que se intensifica no estado do Pará, inserido na Amazônia Paraense. Este estudo tem como objetivo analisar, de forma quantitativa, a acessibilidade à água no estado, com ênfase na comparação entre o município de Paragominas-PA e outros municípios paraenses. A metodologia baseou-se na análise de dados secundários provenientes do Sistema Nacional de Informações sobre o Saneamento (SNIS), da Pesquisa Nacional de Saneamento Básico (IBGE) e de relatórios da Agência Nacional de Águas (ANA), além da aplicação de questionários de percepção com 40 participantes do município de Paragominas. Os resultados evidenciam, que embora os resultados apresentem baixo índice de cobertura de abastecimento, Paragominas destaca-se com elevado percentual de atendimento (95,75%), semelhante a capital Belém. A percepção dos usuários indicou alto nível de satisfação (ISA = 1,00), porém baixa confiança no consumo direto da água (ICC = 0,3), o que revelou uma contradição entre regularidade do abastecimento e confiança no consumo direto. Conclui-se que, apesar dos avanços pontuais, persiste desigualdades sociais significativas relacionadas a confiabilidade do serviço, sendo necessárias políticas públicas integradas, investimentos estruturais e estratégias de comunicação para o fortalecimento da confiança da população. Desta forma o estudo contribui para o abastecimento hídrico do Pará, de maneira que assegure o Direito Humano de acesso à água. Objetivo: O objetivo deste estudo é analisar a acessibilidade à água potável no Estado do Pará, com base em dados de fontes oficiais, por meio da comparação entre os indicadores de abastecimento de água do município de Paragominas-PA, da capital de Belém e de outros municípios paraenses, visando avaliar o percentual da população atendida e identificar desafios e possibilidades para ampliação do acesso a água tratada e segura. Referencial Teórico: O acesso a água tratada e o saneamento básico foi reconhecido, em 2010, pela Organização das Nações Unidas (ONU) como direito humano fundamental, indispensável, à garantia da dignidade, da saúde e do bem-estar da população. Esse reconhecimento representa um marco normativo relevante, ao orientar à formulação de políticas públicas, voltadas a redução das desigualdades no acesso aos serviços de abastecimento de água e saneamento básico. Dentro desse contexto, destaca-se o papel dos Objetivos de Desenvolvimento Sustentável (ODS), especialmente a ODS 6, que estabelece como meta assegurar a disponibilidade e a gestão sustentável da água e do saneamento para todos. Esta diretriz reforça a importância de estudos que analisem as condições de acesso à água potável, sobretudo na região Amazônica, que ainda é marcada por desigualdades sociais. A distribuição desigual de

serviços sociais ainda é uma grande dificuldade. A equidade em acesso é uma condição para o bem-estar populacional. Neste ponto é possível aferir a importância da Governança da água, desempenhando um importante papel no Brasil e no Estado do Pará de maneira que pode orientar a organização dos sistemas de abastecimento e a formulação de novas políticas públicas voltadas aos recursos hídricos, para que de certa forma a justiça social comece a trazer frutos relacionados ao acesso igualitário. Atualmente a governança dos recursos hídricos no Pará contam com a Política Nacional de Saneamento Básico (lei 11.445/2007); a Agência Nacional de Água e Saneamento Básico (ANA); Secretaria de Estado de Meio Ambiente (SEMAS-PA); A Comissão Estadual de Recursos Hídricos, o Comitê de Bacia e a Companhia de Saneamento do Pará (COSANPA). Dessa forma este estudo é de suma importância para a contribuição para políticas públicas, com o aprimoramento voltado ao acesso à água e Governança Hídrica no Estado como um todo. Também é um importante tema a ser discutido no mundo acadêmico. Método: O presente estudo caracteriza-se como uma pesquisa de abordagem mista (quantitativa e qualitativa), com objetivos exploratórios e descritivos, voltado ao acesso à água potável no estado do Pará. A etapa quantitativa baseou-se coleta e análise de dados secundários provenientes de bases oficiais, incluindo o Sistema Nacional de Informações sobre Saneamento (SNIS), a Pesquisa Nacional de Saneamento Básico (PNSB), realizada pelo Instituto Brasileiro de Geografia e Estatística (IBGE), e relatórios da Agência Nacional de Águas e Saneamento Básico (ANA). Adicionalmente, foi realizada análise documental da Portaria GM/MS nº 888/2021, que estabelece os padrões de potabilidade da água para consumo humano no Brasil, a fim de subsidiar a discussão sobre qualidade e segurança da água distribuída. A etapa qualitativa consistiu na realização de pesquisa de campo no município de Paragominas-PA, por meio da aplicação de questionário estruturado junto à população local. A amostra foi composta por 40 participantes selecionados por conveniência, em local público de grande circulação. O instrumento contemplou questões relacionadas à percepção da qualidade da água, regularidade do abastecimento e nível de satisfação com os serviços prestados. Os dados quantitativos foram analisados por meio de estatística descritiva, com cálculo de frequências e percentuais, possibilitando a comparação entre os indicadores avaliados. Para a análise dos dados qualitativos, adotou-se abordagem descritiva, buscando identificar padrões de percepção dos usuários. Além disso, foram elaborados dois indicadores sintéticos: o Índice de Satisfação do Abastecimento (ISA) e o Índice de Confiança no Consumo (ICC), com o objetivo de mensurar, respectivamente, o nível de satisfação dos usuários com o serviço prestado e a confiança no consumo direto da água. Esses indicadores variam de 0 a 1, sendo que valores mais próximos de 1 indicam melhores condições de avaliação. Resultados e Discussão: Os resultados obtidos evidenciam uma percepção predominante positiva por parte dos participantes em relação a qualidade e distribuição de água fornecida no município de Paragominas-PA. A maioria dos respondentes demonstrou satisfação com os serviços prestados pela autarquia municipal, indicando que o abastecimento, tem atendido, de forma geral, às demandas básicas. Implicações da Pesquisa: A pesquisa apresenta implicações relevantes para o saneamento básico e a gestão de recursos hídricos ao evidenciar desigualdades no acesso à água potável no estado do Pará. Os resultados indicam a necessidade de se aprimorar as políticas públicas, tanto no âmbito da expansão da cobertura, como no fortalecimento da confiança da população quanto à qualidade da água distribuída. Os indicadores propostos, como o Índice de Satisfação do Abastecimento (ISA) e o Índice de Confiança no Consumo (ICC), mostraram-se ferramentas úteis para o monitoramento e a tomada de decisão, contribuindo para estratégias mais eficientes e adequadas à realidade local. Originalidade/Valor: O estudo contribui para a literatura ao oferecer uma análise quantitativa atualizada sobre a

acessibilidade à água tratada no Estado do Pará por meio dos dados oficiais e referências teóricas sobre o direito humano à água, justiça social e governança hídrica.

Palavras-chave: Acessibilidade. Água Tratada. Direitos Humanos. Recursos Hídricos.

RESUMEN

El acceso al agua potable en Brasil es significativamente desigual, una realidad que se intensifica en el estado de Pará, ubicado en la región amazónica de Pará. Este estudio tiene como objetivo analizar cuantitativamente la accesibilidad al agua en el estado, con énfasis en la comparación del municipio de Paragominas-PA con otros municipios de Pará. La metodología se basó en el análisis de datos secundarios del Sistema Nacional de Información Sanitaria (SNIS), la Encuesta Nacional Básica de Saneamiento (IBGE) e informes de la Agencia Nacional del Agua (ANA), además de la aplicación de cuestionarios de percepción a 40 participantes del municipio de Paragominas. Los resultados muestran que, si bien la tasa de cobertura general es baja, Paragominas se destaca con un alto porcentaje de servicio (95,75%), similar al de la capital, Belém. La percepción de los usuarios indicó un alto nivel de satisfacción (ISA = 1,00), pero baja confianza en el consumo directo de agua (ICC = 0,3), lo que revela una contradicción entre la regularidad del suministro y la confianza en el consumo directo. Se concluye que, a pesar de algunos avances, persisten importantes desigualdades sociales relacionadas con la fiabilidad del servicio, lo que requiere políticas públicas integradas, inversiones estructurales y estrategias de comunicación para fortalecer la confianza pública. Por lo tanto, este estudio contribuye al suministro de agua en Pará, garantizando el derecho humano al acceso al agua. Objetivo: El objetivo de este estudio es analizar el acceso al agua potable en el estado de Pará, con base en datos de fuentes oficiales, comparando los indicadores de suministro de agua en el municipio de Paragominas-PA, la capital Belém y otros municipios de Pará, con el fin de evaluar el porcentaje de la población atendida e identificar desafíos y posibilidades para ampliar el acceso a agua tratada y segura. Marco teórico: El acceso al agua tratada y al saneamiento básico fue reconocido en 2010 por las Naciones Unidas (ONU) como un derecho humano fundamental, indispensable para garantizar la dignidad, la salud y el bienestar de la población. Este reconocimiento representa un hito normativo significativo, que guía la formulación de políticas públicas dirigidas a reducir las desigualdades en el acceso al suministro de agua y a los servicios básicos de saneamiento. Dentro de este contexto, destaca el rol de los Objetivos de Desarrollo Sostenible (ODS), especialmente el ODS 6, que establece como meta asegurar la disponibilidad y la gestión sostenible del agua y el saneamiento para todos. Esta directriz refuerza la importancia de los estudios que analizan las condiciones de acceso al agua potable, especialmente en la región amazónica, que todavía está marcada por desigualdades sociales. La distribución desigual de los servicios sociales sigue siendo una dificultad importante. La equidad en el acceso es una condición para el bienestar de la población. En este punto, es posible evaluar la importancia de la gobernanza del agua, que juega un rol significativo en Brasil y en el estado de Pará, de manera que puede guiar la organización de los sistemas de suministro y la formulación de nuevas políticas públicas enfocadas en los recursos hídricos, para que la justicia social pueda comenzar a dar frutos relacionados con el acceso igualitario. Actualmente, la gobernanza de los recursos hídricos en Pará se basa en la Política Nacional de Saneamiento Básico (Ley 11.445/2007); la Agencia Nacional de Agua y Saneamiento Básico (ANA); la Secretaría de Estado del Medio Ambiente (SEMAS-PA); la Comisión Estatal de Recursos Hídricos; el Comité de Cuenca; y la Compañía de Saneamiento de Pará (COSANPA). Por lo tanto, este estudio es de suma importancia para contribuir a las políticas públicas, con mejoras enfocadas en el acceso al agua y la gobernanza del agua en el estado en su

conjunto. También es un tema importante para ser discutido en el mundo académico. **Método:** Este estudio se caracteriza como una investigación de métodos mixtos (cuantitativos y cualitativos), con objetivos exploratorios y descriptivos, enfocados en el acceso al agua potable en el estado de Pará. La fase cuantitativa se basó en la recolección y análisis de datos secundarios de bases de datos oficiales, incluyendo el Sistema Nacional de Información Sanitaria (SNIS), la Encuesta Nacional de Saneamiento Básico (PNSB), realizada por el Instituto Brasileño de Geografía y Estadística (IBGE), e informes de la Agencia Nacional de Agua y Saneamiento Básico (ANA). Adicionalmente, se realizó un análisis documental de la Ordenanza GM/MS No. 888/2021, que establece los estándares de potabilidad para el agua potable en Brasil, para respaldar la discusión sobre la calidad y seguridad del agua distribuida. La fase cualitativa consistió en realizar una investigación de campo en el municipio de Paragominas-PA, mediante la aplicación de un cuestionario estructurado a la población local. La muestra consistió en 40 participantes seleccionados por conveniencia en un lugar público con mucho tránsito. El instrumento incluyó preguntas relacionadas con la percepción de la calidad del agua, la regularidad del suministro y el nivel de satisfacción con los servicios prestados. Los datos cuantitativos se analizaron mediante estadística descriptiva, con cálculo de frecuencias y porcentajes, lo que permitió la comparación entre los indicadores evaluados. Para el análisis de los datos cualitativos, se adoptó un enfoque descriptivo, buscando identificar patrones de percepción del usuario. Además, se desarrollaron dos indicadores sintéticos: el Índice de Satisfacción con el Suministro (ISA) y el Índice de Confianza en el Consumo (ICC), con el objetivo de medir, respectivamente, el nivel de satisfacción del usuario con el servicio prestado y la confianza en el consumo directo de agua. Estos indicadores varían de 0 a 1, con valores más cercanos a 1 que indican mejores condiciones de evaluación. **Resultados y Discusión:** Los resultados obtenidos muestran una percepción predominantemente positiva por parte de los participantes respecto a la calidad y distribución del agua suministrada en el municipio de Paragominas-PA. La mayoría de los encuestados expresó satisfacción con los servicios prestados por la autoridad municipal, indicando que el suministro de agua ha satisfecho en general las necesidades básicas. **Implicaciones de la investigación:** Esta investigación presenta implicaciones relevantes para el saneamiento básico y la gestión de los recursos hídricos, al destacar las desigualdades en el acceso al agua potable en el estado de Pará. Los resultados indican la necesidad de mejorar las políticas públicas, tanto en términos de ampliar la cobertura como de fortalecer la confianza pública en la calidad del agua distribuida. Los indicadores propuestos, como el Índice de Satisfacción con el Suministro de Agua (ISA) y el Índice de Confianza en el Consumo (ICC), demuestran ser herramientas útiles para el monitoreo y la toma de decisiones, contribuyendo a estrategias más eficientes y adecuadas a la realidad local. **Originalidad/Valor:** Este estudio contribuye a la literatura al ofrecer un análisis cuantitativo actualizado de la accesibilidad al agua tratada en el estado de Pará, a través de datos oficiales y referencias teóricas sobre el derecho humano al agua, la justicia social y la gobernanza del agua.

Palabras clave: Accesibilidad. Agua Tratada. Derechos Humanos. Recursos Hídricos.

1 INTRODUCTION

International Organizations, known worldwide, such as: United Nations (UN), Food and Agriculture Organization of the United Nations (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), warn that water scarcity tends to intensify in the coming decades. Estimates indicate that by 2025, approximately 1.8 billion people will live in regions with characteristics of water scarcity. It can lead to more than two-thirds of the world's population facing water stress.

According to information from UN-Water, water scarcity has become a growing problem in several regions of the world. Some of the reasons are demand exceeding supply, population growth and climate change that has been directly impacting. Water is a finite resource whose availability varies according to geographic location and according to the pressures for use, this is a factor that aggravates the problem when the quantity and quality of available water decreases, which contributes to situations of water stress.

Water, as it is a finite resource, requires proper management. Population growth on a global scale, combined with continuous economic development, has intensified the pressure on water resources, resulting in the inability of several countries to meet the growing demand for water.

Water is essential for the maintenance of life on earth. However, their distribution on the planet is uneven: approximately 97% are found in the ocean; 2.2% are stored in glaciers; and only 0.8% correspond to available fresh water. Of this 0.8% of freshwater available, 97% of this water is underground and 3% is available superficially (Von Sperling, 2022).

It is noteworthy that surface water resources are, in general, more easily accessible, while groundwater requires greater technical and operational complexity for its collection.

According to the report of the United Nations Conference on Water, approximately 26% of the world's population does not have access to safe drinking water, and about 46% do not have adequate basic sanitation services.

Ordinance No. 888 of the Ministry of Health establishes guidelines for the control and surveillance of the quality of water that will be destined for human consumption. The ordinance defines potability standards that must be met, specifying parameters that characterize drinking water with compliance with microbiological criteria for this (Brasil, 2021).

These potability standards must be met so that there is no damage to human health, since it is important to regulate the internal temperature and the very functioning of the body.

In Brazil, especially in the Amazon region, high water availability can convey a perception of water abundance. However, it is important to emphasize that quantity does not translate

quality, the current risks are made up of its potability (Sottili, 2022).

Water quality can be affected by several factors such as natural phenomena, through atmospheric precipitation and runoff (climatic, geological and hydrological characteristics) and through human action such as land occupation, agricultural practices, industrial and domestic waste (Brasil, 2005).

Currently there are three distinct conceptions about water quality: the desired quality, necessary to meet a certain use; the actual quality available, which corresponds to the current conditions of that water resource; and the intended quality, which represents the quality standard that is desired for that water through management and control actions.

The management of water resources within the country faces several structural challenges, we can first talk about the territorial extension, which results in a broad complex monitoring of resources. Along with this factor, economic and population growth intensifies the demand for water, which results in pressure on supply systems. Finally, the lack of priority attributed in the political sphere to the implementation of public policies makes everything more difficult.

The objective of this study is to analyze data from official sources to verify the accessibility of water in the State of Pará in a quantitative way. It seeks to evaluate the percentage of the population served with access to treated and safe water in Pará, in addition to comparing the water supply indicators in the state capital with the municipality of Paragominas-PA and how it would be possible to expand access. Additionally, it is intended to analyze the perception with an interview in a public place of easy access and without identification to acquire information about the Paragominas Sanitation Agency (SANEPAR).

2 THEORETICAL FRAMEWORK

The quality of water and drinking standards need concreteness so that society in general does not suffer losses. For each use intended for water, there are standards to be followed. In Brazil, the National Council for the Environment (CONAMA) establishes the classification of water bodies and the guidelines for their classification. As provided for in article 3 of CONAMA Resolution No. 357/2005:

"Art.3 - The fresh, brackish and saline waters of the National Territory are classified, according to the quality required for their preponderant uses, into thirteen quality classes."

Basic sanitation is essential, as proper sewage treatment prevents domestic, industrial,

and hospital waste from being thrown directly into contact with rivers and lakes. According to the World Health Organization (WHO), about 80% of diseases in developing countries come from contaminated water, that is, from diseases arising from waterborne water. In addition, the better the water is collected, the lower the expenses with its treatment. A better water supply reduces the incidence of waterborne diseases.

The absence of adequate water supply and sanitation services disproportionately affects women and children, as it compromises hygiene practices and increases exposure to waterborne diseases, especially diarrheal diseases. Studies warn that the use of water sources and sanitation systems that are not improved are associated with a higher occurrence of childhood diarrhea, evidencing the direct relationship between poor health and the health impacts of these population groups (Asgedom et al., 2023).

The United Nations (UN), through General Assembly Resolution A/RES/64/292 of 2010, formally recognized access to drinking water and basic sanitation as a fundamental human right, indispensable to the guarantee of human dignity, health and well-being. However, despite the efforts for this recognition at the international normative level and the commitments assumed by Brazil, there is still a distance between the legal consecration of this right and its practical implementation. The evidence appears with the permanence of inequalities in access to quality water and basic sanitation services.

The Sustainable Development Goals (SDGs), especially goal 6, highlight water and sanitation as one of the goals to achieve sustainable development in the country. To achieve this goal, the availability and sustainable management of water and sanitation for all must occur.

When it comes to the Amazonian context, this contradiction between the objective and reality is evident. Although the Amazon is home to one of the largest water availability in the country and on the planet, the population encounters difficulties in relation to access to water and adequate sanitation, with the most affected being rural, riverside and urban periphery populations

The difficulty in implementing this objective in the Amazon reveals not only technical and economic obstacles, but also challenges related to water governance, territorial equity and socio-environmental justice, reinforcing the need for public policies that consider regional specificities for the effective realization of the human right to water. All of this causes socio-environmental vulnerability.

Studies indicate that this reality is due to socio-spatial inequalities, precarious infrastructure and failures in the governance of supply services, which in fact forms the paradox between water abundance and social exclusion in access to water (Castro, 2007; Hellerr;

Castro, 2013).

The Northern Region of Brazil has a total population of approximately 17.3 million inhabitants, according to data from the Brazilian Institute of Geography and Statistics (IBGE).

According to data from the National Sanitation Information System (SNISA), 64.2% of the population in the northern region is served with water supply, while only 14.7% have sanitary sewage service.

These data show that almost half of the population in the northern region has not had access to water supply and 85.3% of the population does not have sanitary sewage. Within this statistic, the treatment of this generated sewage has 19.8% of treatment.

The rate of service of the population with water supply in the state of Pará is 55.4%, for sanitary sewage the service is 9.2% of the population, and almost the entire population (90.8%) without service for sanitary sewage. Of this estimate, treated sewage in the state is 8.7%

The lack of service when it comes to basic sanitation is remarkable, the reality needs to change urgently so that there is a better quality of life for all the state population.

Access to drinking water is intrinsically linked to the principle of the dignity of the human person, being indispensable for health, especially when it comes to the minimum condition for the existence of a dignified life. It is an essential factor for meeting the basic needs of the individual such as drinking, preparing food, and having personal hygiene.

In this sense, Luís Roberto Barroso, in his work *The Dignity of the Human Person in Contemporary Constitutional Law*, highlights dignity as a structuring principle of the Constitutional State, from which other fundamental rights radiate, comprising dimensions that involve the intrinsic value of the human person, individual autonomy and the social dimension of dignity (BARROSO, 2012).

The principle of human dignity is a pillar for the protection of several other fundamental rights such as the right to life, health, education, housing and food. It is unfeasible to enforce all other rights without the minimum, that is, access to drinking water and basic sanitation services.

In this way, the research becomes relevant given the insufficiency in access both for coverage and for the quantity and quality of water and sanitation. This reality compromises other rights that are guaranteed in the Universal Declaration of Human Rights and in the Federal Constitution of 1988 itself, evidencing the distance between the norm and the practical realization of these rights.

The municipality of Paragominas has distanced itself from state statistics, being notoriously one of the municipalities that seek to advance more and more in access to water. Currently, the municipality has an estimated population of 105,550 inhabitants, the total water

service in the municipality is 95.75%.

The municipality is one of the few in the state that is closer to the capital (Belém) that has total access to water at 95.52% and has distanced itself from the little access to other municipalities such as Portel with access of 12.07%; Altamira with 49.8%; São Felix do Xingu, with 4%, among others.

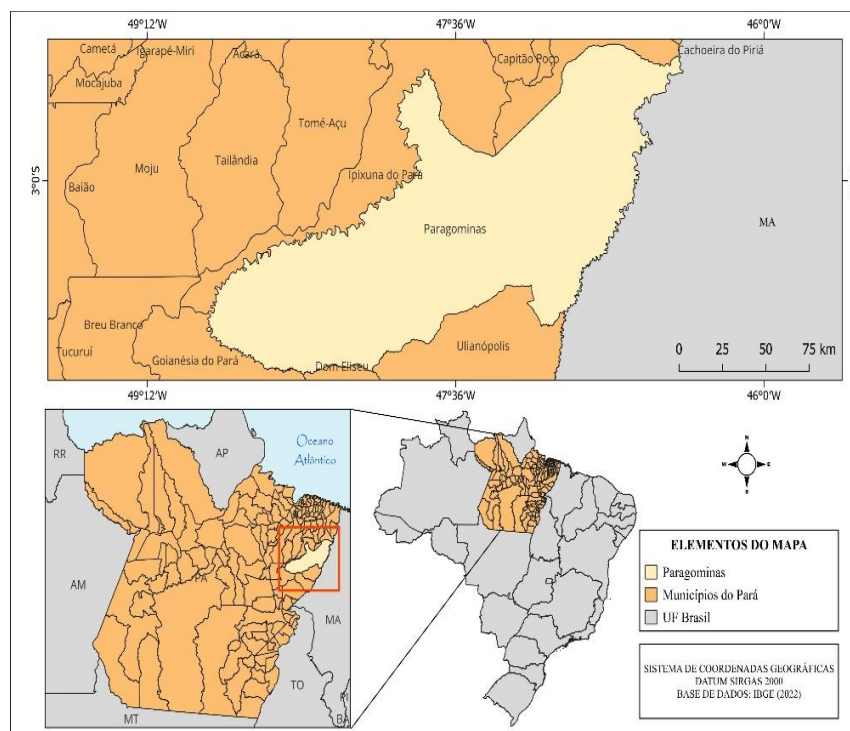
What has been evidenced as the main difference is the water supplier in which it is a municipal autarchy - SANEPAR, distancing itself from the current provider in most of the municipalities in the state that use COSANPA. The Municipality of Paragominas-PA is the focus of this study to obtain a perspective of accessibility to drinking water.

2.1 CHARACTERIZATION OF THE STUDY AREA

The study area covers the municipality of Paragominas, in the state of Pará, as shown in Figure 1. This municipality is located in the North of Brazil, belonging to the region of the Capim River and according to the regional geographic division, prepared by the Brazilian Institute of Geography and Statistics (IBGE) of 2023 it is located in the southeast region of Pará. It has an approximate area of 19,341.9 km² and a population of 105,538 inhabitants (IBGE, 2024).

Figure 1

Location of the Municipality of Paragominas, State of Pará



Source: Prepared by the authors based on data obtained from IBGE (2022).

3 METHODOLOGY

The present study is characterized as a mixed approach research (quantitative and qualitative), with exploratory and descriptive objectives. The methodology adopted is structured in four stages:

3.1 BIBLIOGRAPHIC AND DOCUMENTARY RESEARCH:

A bibliographic, jurisprudential, documentary and legislative survey on basic sanitation was carried out. Thus, it based the legal analysis of the right to water on current legislation and doctrine.

3.2 DATA COLLECTION (SNIS):

Data were extracted from the National Sanitation Information System (SNIS). The analysis was based on indicators of coverage of water supply in the state of Pará, so that a direct comparison with the municipality of Paragominas was established.

3.3 FIELD RESEARCH:

Data collection took place in January 2026, through a satisfaction survey on the water supply at Praça Célio Miranda, downtown Paragominas-PA. The research instrument was applied in accordance with the ethical precepts of research with human beings; The anonymity of the participants was fully preserved, and participation occurred on a voluntary basis.

A structured questionnaire consisting of nine questions was applied, as shown in Table 1, focusing on the perception of quality, regularity and satisfaction with the services provided by the Paragominas Sanitation Agency (SANEPAR).

The sample was composed of 40 (forty) participants who passed through the place, and the approach was based on accessibility criteria, due to the large flow of citizens from different neighborhoods.

Initially, the application of the instrument to a universe of approximately 100 respondents was estimated. However, due to operational limitations, the final sample consisted of 40 participants. The sample allowed the analysis to be carried out in a consistent manner, providing the necessary support regarding the users' perception of the service provided.

Table 1

Satisfaction questionnaire of the Paragominas Sanitation Agency

What age, gender and place of residence?
What was the water supply like before the creation of SANEPAR?
How do you currently perceive the water supply by SANEPAR?
Is there an interruption in supply? If so, how often?
What is your opinion about water quality?
Do you feel any unpleasant taste or odor?
Do you trust the use of water for food production?
Do you trust the use of water for human consumption?
Do you identify the presence of color in the water?

Source: Authors.

3.4 ANALYSIS OF THE DATA OBTAINED:

The collected data will be analyzed in two descriptive stages, through the direct counting of the number of responses in each response category and the conversion of this value into a percentage so that it allows the proportional comparison between the different items of the questionnaire.

These data were treated manually, following the rule of three, where the total number of interviewees (N=40) corresponds to 100%; identification and "n" as the number of people who chose the option.

In addition, two indicators were developed with the objective of systematizing the perception of users regarding water supply services and the proportion of confidence for direct consumption.

4 SANEPAR SATISFACTION QUESTIONNAIRE

During the study, a field research was carried out to understand the population's perception of population satisfaction with the municipality responsible for the supply and sanitation of the municipality, as shown in Table 2.

The collection took place in a public space with a large circulation of people so that data could be collected so that we could get the largest possible number of perceptions.

Table 2

Satisfaction questionnaire of the Paragominas Sanitation Agency

Number	Question	Response Category	Number of responses
1	What is the Age, Gender and Neighborhood of Residence?	18 to 29 years old 30 to 44 years old 45 to 59 years old 60 years or older Gender: Female; male; another; I prefer not to inform	40

2	What was the water supply like before the creation of SANEPAR?	Terrible Using wells in an alternative way He did not know how to inform	40
3	How do you currently perceive the water supply by SANEPAR?	Very Satisfied Good Bad	40
4	Is there an interruption in supply? If so, how often?	Frequent interruption Eventual interruption There is no interruption	40
5	What is your opinion about water quality?	Very Satisfied Good Bad	40
6	Do you feel any unpleasant taste or odor?	Yes No	40
7	Is the water supplied suitable for food production?	Yes No	40
8	Do you consider the water supplied fit for human consumption?	Yes No	40
9	Do you identify the presence of color in the water?	Yes No	40

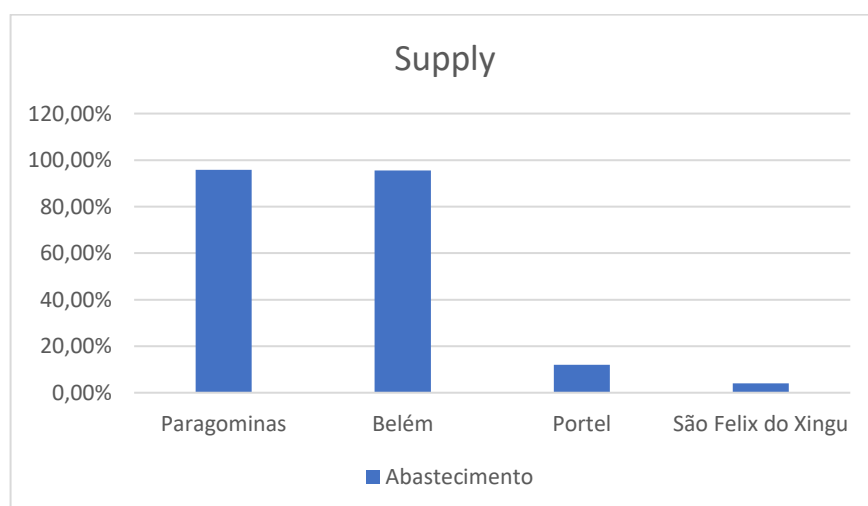
Source: Authors.

5 ANALYSIS OF RESULTS AND DISCUSSIONS:

Graph 1 shows the comparison between the water supply service indexes between the North Region, the state of Pará and selected municipalities. It is observed that the city of Paragominas has a high coverage rate (95.75%), above the state average of 55.4% and the regional average of 64.2%, approaching the indicators of the state capital.

Figure 2

Comparison of access to water supply in the North Region, Pará and selected municipalities.



Source: SNIS (2023), prepared by the authors (2026).

The contrast with the other municipalities located in the interior such as Portel (12.07%) and São Felix do Xingu (4%) have low levels of coverage, which demonstrates the inequalities of access within the state of Pará itself.

The following equation was used to analyze the questionnaire data:

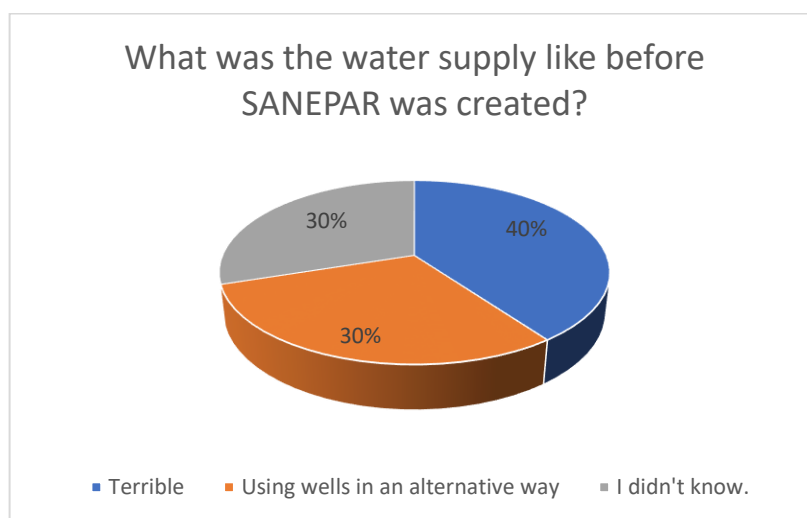
$$P = \frac{n \times 100}{N} \quad (1)$$

Where **P** stands for the percentage; **n** the response group in a response category; **N** total number of respondents.

Among the individuals who answered the questionnaire, 4 (four) were between the ages of 18-29 years; 20 (twenty) between the ages of 30-44 years; and 16 (sixteen) between the ages of 45-59 years.

Figure 3

Users' perception of water supply before the implementation of SANEPAR in Paragominas-PA

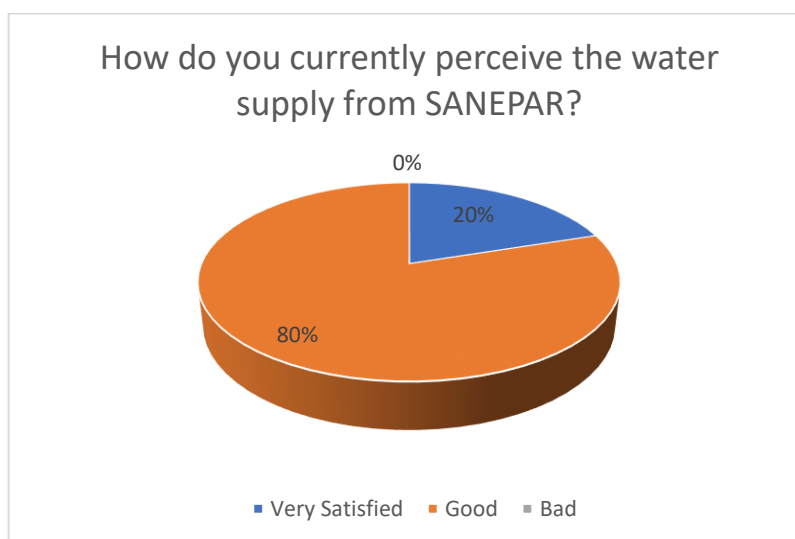


Source: Prepared by the authors, 2026.

Before the implementation of SANEPAR, 40% of the respondents classified the supply as very poor, while 30% reported the use of alternative sources, such as wells, evidencing the precariousness of the previous system. And 30% did not know how to inform, as shown in Figure 3.

Figure 4

Users' perception of the water supply by SANEPAR in the municipality of Paragominas-PA

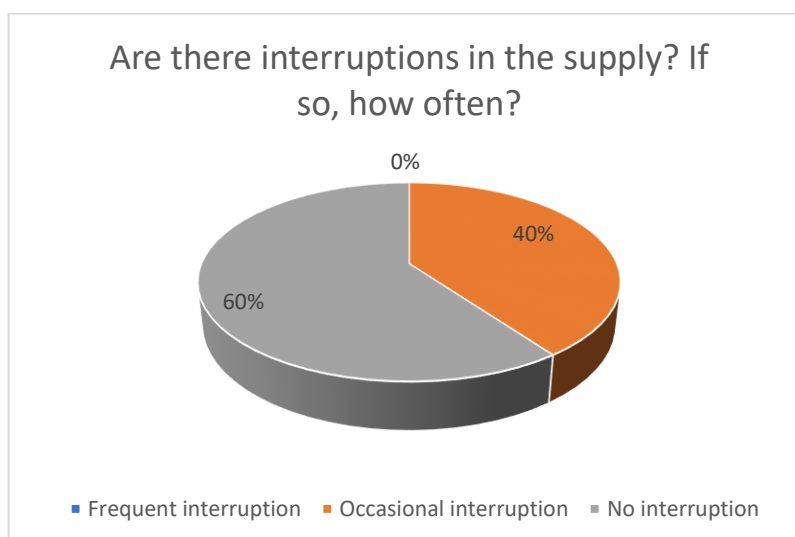


Source: Prepared by the authors, 2026.

Faced with the question about how the water supply is currently perceived by the current supplier SANEPAR, 80% of the participants evaluated the service as "good" and 20% classified the supply as "very satisfied", with no record of negative evaluations, as shown in Figure 4. These results indicate a significant improvement in the perception of the service.

Figure 5

Frequency of interruptions in the water supply in the municipality of Paragominas-PA



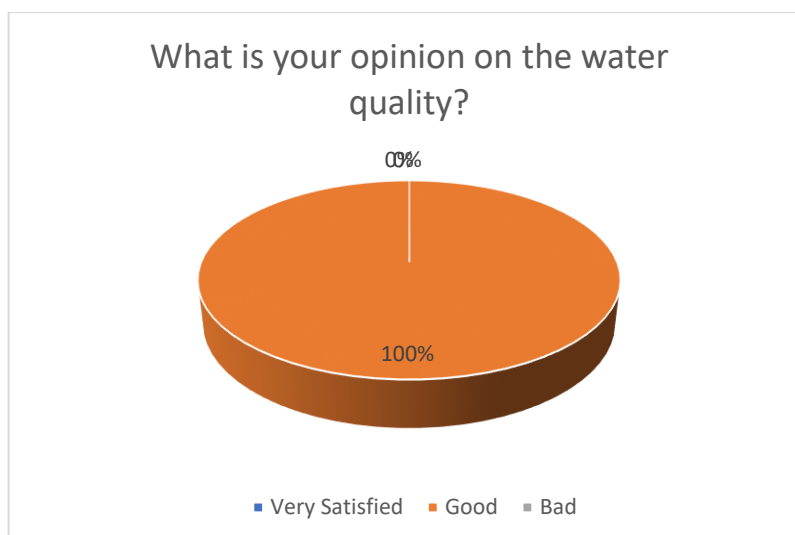
Source: Prepared by the authors, 2026.

In view of the questioning about the interruption in supply, evidenced in Figure 5, it reinforces the positive perception of users regarding the regularity of the service. However, when analyzed together with the Consumption Confidence Index (CCI), it is observed that the

continuity of supply does not necessarily translate into confidence for intake, evidencing the need for actions aimed at transparency and education about water quality.

Figure 6

Water quality



Source: Prepared by the authors, 2026.

Faced with the questioning about the quality of the water, many claimed that it was a good quality. As shown in Figure 6, however, some reported that in rainy periods they notice a certain bleaching in the water, which may be the use of chemicals to maintain the standard required by the Ministry of Health ordinance No. 888.

Figure 7

Taste and odor of water



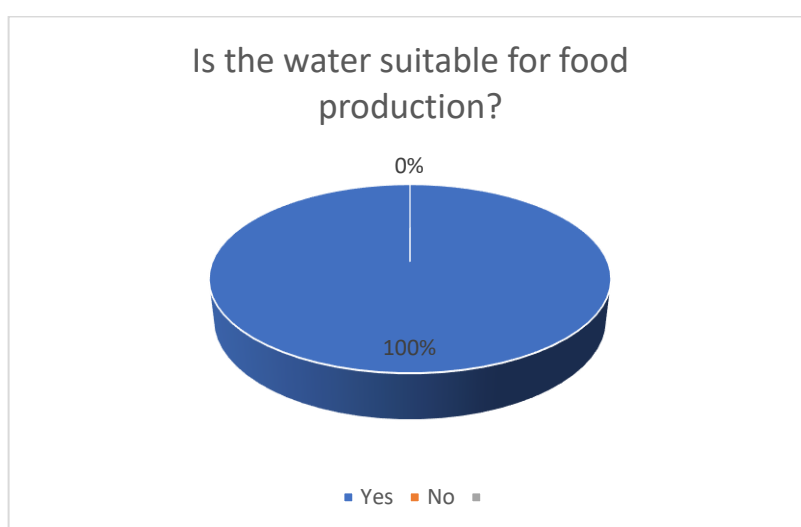
Source: Prepared by the authors, 2026.

The perception of the interviewees regarding the presence of unpleasant taste or odor in the water supplied by SANEPAR demonstrates a totally favorable result. As shown in Figure 7, 100% of the participants stated that they did not perceive any sensory alteration related to odor or taste.

This result reinforces the positive evaluation of users regarding water quality, especially with regard to organoleptic parameters, which are directly perceptible by the population. The absence of unpleasant odor and taste is a relevant indicator of service acceptance, since such characteristics directly influence the population's confidence and water consumption.

Figure 8

Population's perception of water quality

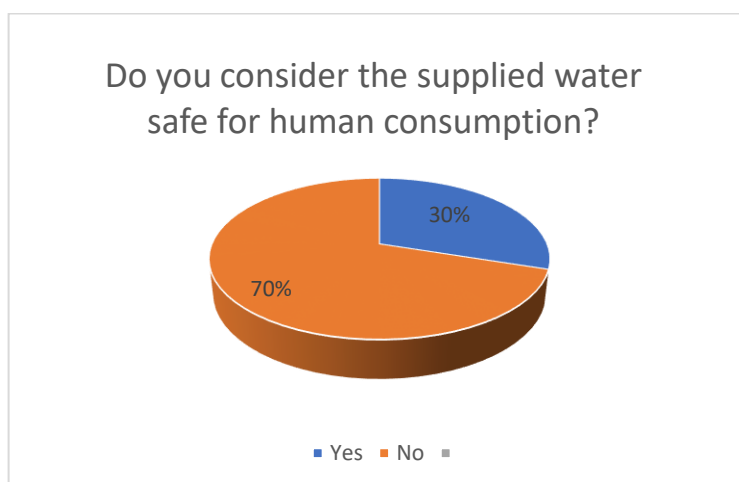


Source: Prepared by the authors, 2026.

When it comes to the confidence for the use of water in food production, all of them answered that they consider water suitable for this purpose. As shown in Figure 8, however, some, as we will see in the next graph (Figure 9), also consider it good enough for their own consumption.

Figure 9

Perception of the potability of water for human consumption

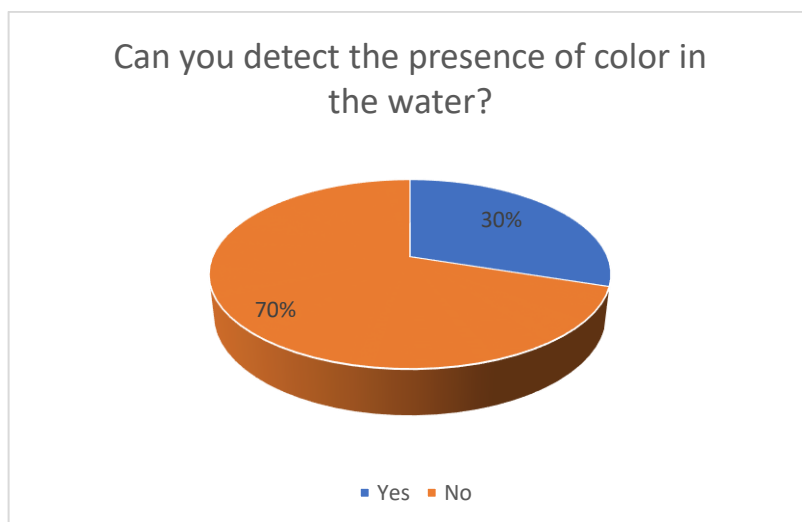


Source: Prepared by the authors, 2026.

Regarding those questioned about the adequacy of the water supplied for human consumption, 70% of the interviewees stated that they did not trust its use for direct ingestion, while 30% stated that they trusted the use of water for this purpose.

Figure 10

Population's perception of the presence of color in the water



Source: Prepared by the authors, 2026.

70% answered that they did not identify the presence of color in water, but 30% stated that they identified a whiter color at some times of the year, even compared to fruit salt, as shown in Figure 10.

The data collected are important and present a positive way in relation to the perception of water supply, especially when compared to other municipalities in the state.

It is possible to observe a predominantly positive perception on the part of the participants in relation to the quality and distribution of water in the municipality of Paragominas-PA.

Most respondents showed satisfaction with the services provided, showing that the supply has been meeting the basic needs of the population. The data show a good starting point for the perception of users of the services provided by SANEPAR.

Expanding the application of this questionnaire is essential so that it enables data collection on a larger scale, increasing the representativeness of users' perceptions. Even so, the present study constitutes an important starting point, being an initial model the current model of water supply by SANEPAR for the improvement in the quality of water distribution in the state of Pará.

With the data obtained, the Supply Satisfaction Index (ISA) was elaborated. Its objective is to measure the general level of satisfaction of users in relation to the service provided, considering the positive responses of good and satisfied. The ISA result will vary between 0 and 1, in which values closer to 1 indicate a higher level of user satisfaction.

Formula:

$$ISA = \frac{(\% \text{ positive responses})}{100} \quad (2)$$

From the participants' answers, 80% were considered good and 20% were very satisfied. Applying it to the formula, we will have the ISA of 1.00. This result indicates a high level of satisfaction of users of the services provided by the current supplier in the water supply.

The second indicator developed refers to the Consumer Confidence Index (CCI). Here it is possible to see that 30% of the answers say they trust the use for consumption of the water supplied and the others do not trust for such use.

Formula:

$$ICC = \frac{(\% \text{ who trust in consumption})}{100} \quad (3)$$

The CCI in this case had the result at 0.3 where it is visible that the population's confidence in self-consumption is still low, when compared to the portion that does not trust the use for ingestion.

In a joint analysis of the indicators elaborated: Supply Satisfaction Index (ISA) and Consumption Confidence Index (CCI), it is evident that the ISA presented the maximum (1.0),

being a high level of satisfaction. This results in aspects of regularity in the provision of services and attendance to basic demands.

The CCI, which presented a value of (0.3), shows the low level of confidence of the population in the direct consumption of water. It is evident that there is a contradiction between satisfaction with the service provided and the perception of the quality of the water for ingestion.

The explanation may be based on sensory perceptions such as the change in color at certain times and lack of information about the treatment process of the water itself. Thus, they are indicators that demonstrate the evaluation of efficiency in the provision of the service, but fragility in terms of safety in consumption.

6 CONCLUSION

Water must be treated as a scarce resource, it is possible to see that even today many think that it is an infinite resource.

A very important step towards good management is an Integrated Water Resources Management that provides a framework in which governments can align water use patterns and the needs and demands of different users, as well as their priorities.

This scenario, despite efforts in Brazil by Law No. 9,433/1997 (Water Law), is still occurring in an incipient way to materialize, given the difficulty in collecting and systematizing data, as well as the lack of interest and priority given to the theme by political managers.

It is interesting to observe the approval of the respondents in front of the service provider company in the municipality of Paragominas-PA, which is a different metric in contrast to the other municipalities in the state of Pará that do not obtain an adequate supply and a considerable population failure. It would be a model to follow, or at least, an initial model for changes, because although the municipality stands out, there is still a lack of improvements that serve the population as it deserves.

These results suggest that the perception of quality and supply is linked to the regularity of supply and reliability of the service. Even if initially, the regulations pertaining to drinking water and other regulations have been in line with the regulations. In addition, any discrepancies in the answers indicate that in the future, it will be necessary to deepen future studies, with expansion on a larger scale, in order to obtain a more comprehensive and representative analysis of the population's perception.

Although the indicators point to a positive initial scenario for the provision of the service, it is also evident the need for actions aimed at strengthening the population's confidence, through transparency, environmental education and dissemination about water quality.

The results show that satisfaction with the service does not necessarily imply the confidence of this water for consumption, and it is important to integrate operational management and transparent public communication.

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PREDICTIVE MODELS IN LOGISTICS: THE USE OF ARTIFICIAL INTELLIGENCE IN THE MANAGEMENT OF PURCHASING, INVENTORY, AND DEMAND

MODELOS PREDITIVOS EM LOGÍSTICA: O USO DA INTELIGÊNCIA ARTIFICIAL NA GESTÃO DE COMPRAS, ESTOQUES E DEMANDAS

MODELOS PREDICTIVOS EN LOGÍSTICA: EL USO DE LA INTELIGENCIA ARTIFICIAL EN LA GESTIÓN DE COMPRAS, INVENTARIOS Y DEMANDAS



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ABSTRACT

The increasing incorporation of technologies based on artificial intelligence has generated remarkable transformations in logistics management, especially regarding the application of predictive models used in functions related to purchasing, inventory management, and demand analysis. These changes have enabled improvements in logistics processes, optimizing operations and bringing greater efficiency to the execution of these essential

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activities. In this context, the use of data and the adoption of analytical algorithms have allowed a significant increase in forecasting accuracy, while also improving the coordination of different operations within an organization. Consequently, this has favored decision-making processes that are more consistent, particularly in an organizational environment that is becoming increasingly dynamic and integrated, reflecting the complexity and interaction among various areas and processes. The general objective of this research is to analyze the application of predictive models based on artificial intelligence in the management of purchasing, inventory, and demand, aiming at the optimization of logistics processes and the improvement of decision-making. Regarding the methodology, a qualitative approach was adopted, focused on a detailed understanding of the implications of using artificial intelligence in logistics. As a research procedure, a literature review was conducted through the systematic analysis of relevant scientific publications, enabling the construction of a consistent theoretical basis for the development of the study. In summary, the research demonstrated that the application of predictive models based on artificial intelligence in the management of purchasing, inventory, and demand contributes to the optimization of logistics processes and to improved decision-making by promoting greater forecasting accuracy, better resource allocation, and higher operational efficiency throughout the supply chain.

Keywords: Artificial Intelligence. Predictive Models. Inventory Management. Logistics.

RESUMO

A crescente incorporação de tecnologias que possuem como fundamento a inteligência artificial tem gerado transformações notáveis na administração logística, principalmente no que diz respeito à aplicação de modelos preditivos, os quais são utilizados nas funções relacionadas a compras, gerenciamento de estoques e análise de demandas. Essas mudanças têm possibilitado um aprimoramento nos processos logísticos, otimizando as operações e trazendo uma maior eficiência na condução dessas atividades essenciais. Nesse cenário, a aplicação de dados e a adoção de algoritmos analíticos têm permitido um aumento significativo na precisão das previsões, ao mesmo tempo em que melhoram a coordenação das diferentes operações dentro de uma organização. Isso, conseqüentemente, tem favorecido a realização de decisões que se mostram mais consistentes, especialmente em um contexto organizacional que se torna cada vez mais dinâmico e integrado, refletindo a complexidade e a interação entre diversas áreas e processos. O objetivo geral desta pesquisa consiste em analisar a aplicação de modelos preditivos baseados em inteligência artificial na gestão de compras, estoques e demandas, visando à otimização dos processos logísticos e à melhoria da tomada de decisão. No que se refere à metodologia, adotou-se uma abordagem qualitativa, voltada à compreensão detalhada das implicações do uso da inteligência artificial na logística. Como procedimento de pesquisa, utilizou-se a revisão bibliográfica, desenvolvida por meio da análise sistemática de produções científicas relevantes, o que possibilitou a construção de uma base teórica consistente para o desenvolvimento do estudo. Em síntese, a pesquisa evidenciou que a aplicação de modelos preditivos baseados em inteligência artificial na gestão de compras, estoques e demandas contribui para a otimização dos processos logísticos e para a melhoria da tomada de decisão, ao promover maior precisão nas previsões, melhor alocação de recursos e maior eficiência operacional ao longo da cadeia de suprimentos.

Palavras-chave: Inteligência Artificial. Modelos Preditivos. Gestão de Estoques. Logística.

RESUMEN

La creciente incorporación de tecnologías basadas en inteligencia artificial ha generado transformaciones notables en la gestión logística, especialmente en lo que respecta a la aplicación de modelos predictivos utilizados en funciones relacionadas con compras, gestión de inventarios y análisis de demandas. Estos cambios han posibilitado una mejora en los procesos logísticos, optimizando las operaciones y aportando una mayor eficiencia en la ejecución de estas actividades esenciales. En este contexto, la utilización de datos y la adopción de algoritmos analíticos han permitido un aumento significativo en la precisión de las previsiones, al mismo tiempo que mejoran la coordinación de las diferentes operaciones dentro de una organización. Esto, en consecuencia, ha favorecido la toma de decisiones más consistentes, especialmente en un entorno organizacional cada vez más dinámico e integrado, reflejando la complejidad y la interacción entre diversas áreas y procesos. El objetivo general de esta investigación consiste en analizar la aplicación de modelos predictivos basados en inteligencia artificial en la gestión de compras, inventarios y demandas, con el propósito de optimizar los procesos logísticos y mejorar la toma de decisiones. En cuanto a la metodología, se adoptó un enfoque cualitativo, orientado a la comprensión detallada de las implicaciones del uso de la inteligencia artificial en la logística. Como procedimiento de investigación, se utilizó la revisión bibliográfica, desarrollada mediante el análisis sistemático de producciones científicas relevantes, lo que permitió la construcción de una base teórica consistente para el desarrollo del estudio. En síntesis, la investigación evidenció que la aplicación de modelos predictivos basados en inteligencia artificial en la gestión de compras, inventarios y demandas contribuye a la optimización de los procesos logísticos y a la mejora de la toma de decisiones, al promover una mayor precisión en las previsiones, una mejor asignación de recursos y una mayor eficiencia operativa a lo largo de la cadena de suministro.

Palabras clave: Inteligencia Artificial. Modelos Predictivos. Gestión de Inventarios. Logística.

1 INTRODUCTION

The increasing digitalization that has been taking place in supply chains has provided a specific impetus for significant transformations in the way various organizations structure and organize their logistics-related operations. This appearance of modernization has been changing not only internal processes, but also impacting the way companies interact with suppliers and customers, leading to a new configuration in resource management and product delivery. In this specific context, the adoption of technologies that use artificial intelligence has facilitated the manipulation and processing of large amounts of data. This, in turn, has contributed to analyses that are not only more accurate, but also to the decisions made being significantly more consistent and reasoned. The use of predictive models fits perfectly into this picture. They are very useful analytical tools that can predict behaviors related to market demand in advance. In addition, these models allow for precise adjustments to inventory levels and improve purchase planning. Thus, its use results in a significant contribution to the operational efficiency of organizations.

At the same time, the complex dynamics of contemporary logistics environments reveal a panorama marked by market fluctuations, the demand for agility in operations and a deeper integration between the various processes involved. This situation requires the implementation of solutions that effectively reduce uncertainties and, at the same time, improve the responsiveness of organizations to these challenges. Thus, the use of artificial intelligence in the processes of purchase management, inventory control, and demand forecasting has become a strategy that is aligned with the new dynamics of the business world. This approach allows for actions that are more data-driven, making them less likely to be based on assumptions that may be wrong, which in turn makes operations more efficient.

The general objective of this research is to analyze the application of predictive models based on artificial intelligence in the management of purchases, inventories and demands, aiming at the optimization of logistics processes and the improvement of decision making. While the specific objectives planned are these: Understand the theoretical and operational foundations of predictive models applied to logistics and supply management; Analyze the application of artificial intelligence in demand forecasting and procurement planning; Evaluate the impacts of predictive models on inventory management and supply chain operational efficiency.

With regard to the aspects related to the methodology used, it is important to emphasize that the approach chosen for this research is qualitative. This methodological choice aims to thoroughly analyze the various nuances and implications that the application of artificial

intelligence can have in this specific field. Regarding the procedure adopted, the decision was made to carry out a bibliographic review, which was carried out through the methodical and systematic analysis of scientific works and productions that are relevant and pertinent to the theme in question. This choice made it possible to develop a solid and consistent theoretical basis, which is fundamental for the proper development of the study itself.

The article in question has been organized in such a way as to contain four distinct sections, each with a specific purpose. The first section is the Introduction, in which both the context related to the topic addressed and the objectives that guided the research are presented. Next, we have the Methodology section, which is dedicated to describing in detail the procedures that were adopted throughout the study. The third section, called Theoretical Foundation, is responsible for discussing and analyzing the main conceptual references that support the research. Finally, the last section is the Final Considerations, where a synthesis of the most relevant results obtained throughout the study is made and referrals based on these findings are also presented.

2 METHODOLOGY

The logistics management of various sectors of the economy has been undergoing significant transformations due to the growing adoption of predictive models based on artificial intelligence in purchasing, inventory, and demand management operations. This innovative model is changing the way companies organize and manage their logistics operations, offering new perspectives and techniques to optimize their processes. This is because an industry that requires a high level of precision in decisions, whether operational or strategic, cannot afford to let variability or competitiveness shape its actions. Institutions need to perform their functions with a precision that adapts to the constant changes and challenges that the market imposes, which highlights the importance of speed and accuracy in the decisions made (Sousa et al., 2026). Therefore, it is essential to conduct a survey on the use of these analytical tools, since such research allows a deeper understanding of how different organizations have structured their logistics processes based on concrete and informational data. The objective of this procedure is, first of all, to make strategic decisions more effective and to ensure greater uniformity between them.

The approach selected and implemented throughout this research is classified as qualitative, aiming mainly to achieve a comprehensive and meticulous understanding of the various phenomena associated with the application of artificial intelligence in the context of logistics. This methodological choice reflects the intention to explore intensively and analytically

the nuances and implications of this technological use in the mentioned sector. This approach enables an in-depth analysis of meanings, interpretations, and relationships that could not be fully understood or evidenced by quantitative analysis methods. Lakatos and Marconi (2017) state that qualitative research allows for an in-depth exploration of the intricate complexity of social phenomena. This approach not only offers a more detailed perspective, but also enhances the analysis by situating it in a broader, more contextualized framework. In the scientific context, this methodology has been widely adopted in several disciplines, facilitating the development of coherent understandings of emerging topics. This use, in turn, enables new forms of analysis and interpretation, which deepens our understanding of current and important phenomena that are emerging in many fields of knowledge.

Regarding the methods, a literature review was carried out as a research procedure. This method involves the thorough research of productions already carried out on the subject, which enables the recognition of concepts, theories and important results. Gil (2022) states that the literature review is an essential step in the preparation of scientific research, as it provides a theoretical and methodological basis for the study and positions the researcher in relation to the current state of knowledge.

The bibliographic review carried out was based on a thorough and rigorous analysis of different categories of sources. These sources include monographs, as well as scientific articles that have been disseminated at relevant academic events. Widely recognized scientific journals were also considered, as well as literary works that deal with specialized themes and that have significant relevance within the scope of the research area. This diversified strategy ensured that the review was thorough and grounded in consistent references. The diversity of sources employed plays an essential role in offering a comprehensive and cohesive perspective on the topic under analysis. This variety of information makes it possible to compare and intersect different perspectives and methodologies, thus enriching the analysis carried out. Lakatos and Marconi (2017) emphasize in a relevant way that the use of multiple sources of information contributes substantially to increasing the credibility of the research carried out. Gil (2022), emphatically emphasizes that the careful and judicious selection of bibliographic material is an essential and decisive factor that directly impacts the quality of the results obtained at the end of the research process.

3 THEORETICAL FOUNDATION

The theoretical foundation was structured in order to ensure a logical and articulated approach to the main elements that support the study. To this end, it was organized into three

complementary topics: 3.1 Fundamentals of predictive models and artificial intelligence in logistics, in which the conceptual and technical bases that guide the application of these tools are discussed; 3.2 Artificial intelligence in demand forecasting and procurement optimization, which examines the use of predictive algorithms in supporting decisions related to procurement planning; and 3.3 Data-driven inventory management and logistics efficiency, aimed at analyzing the impacts of artificial intelligence on cost reduction, balancing inventory levels, and improving operational efficiency. This organization favors the progressive understanding of the theme and ensures coherence in the development of the research.

3.1 FUNDAMENTALS OF PREDICTIVE MODELS AND ARTIFICIAL INTELLIGENCE IN LOGISTICS

The predictive models used in logistics in recent years have been meticulously structured and elaborated from the fusion of various techniques from the field of artificial intelligence. These techniques are highly competent and have the ability to examine and process large volumes of data, as well as being effective in detecting relevant patterns that can support decisions. In this way, this strategy enables companies to operate more efficiently and accurately in their logistics activities. In Logistics 4.0, an innovative concept that is revolutionizing conventional logistics practices, the combination of digital systems with sophisticated analytical algorithms makes it possible to predict behaviors associated with the demand for products and services. In addition, this collaboration results in the optimization of supply flows, which makes operations more efficient. This process also results in the reduction of uncertainties that normally surround logistics operations. As highlighted by the authors Batista, Ikeziri and Freitas (2021), the adoption of artificial intelligence-based tools in the internal logistics operations of companies enhances the analytical capacity of these organizations. This adoption of new technologies also allows decisions to better adjust to market dynamics.

The development of these strategies is closely linked to the progress of Industry 4.0, which has brought new technological paradigms to supply chains. According to De Oliveira Moraes and Alves Moraes (2024), integrating artificial intelligence into a company's logistics operations results in significant efficiency increases, particularly in the areas of demand forecasting and inventory control. From this perspective, predictive models work as analytical tools that integrate past data and current variables, enabling faster reactions that are aligned with fluctuations in the economic scenario.

In technical terms, logistic predictive models are supported by machine learning and time series analysis techniques, which allow the formulation of forecasts from structured and

unstructured data. As stated by Gonzalez et al. (2021), when machine learning algorithms are applied in the supply chain, increased accuracy in forecasting translates into greater integration between the various logistics steps. In this context, Table 1 summarizes the main fundamentals, techniques and applications of these models in the scope of supply management.

Table 1

Fundamentals and applications of predictive models in logistics

Dimension	Description
Theoretical foundations	Based on statistics, data science, and artificial intelligence, with a focus on pattern analysis and predictions
Main techniques	Machine learning, neural networks, regression, time series
Applications in procurement	Demand forecasting, definition of procurement volumes, selection of suppliers
Applications in stocks	Optimization of stock levels, reduction of stockouts and excesses
Applications in distribution	Route planning, deadline forecasting and delivery management
Operational benefits	Greater accuracy in decisions, cost reduction and increased logistics efficiency

Source: Adapted from Gonzalez et al. (2021); Murray et al. (2023); Breviário et al. (2025).

Recent literature also highlights the combination of predictive models and optimization techniques as a promising approach to inventory management. Breviário et al. (2025) propose the integration between linear programming and machine learning algorithms, highlighting that this articulation allows not only to predict demands, but also to define more efficient operational strategies. This perspective expands the role of predictive analysis, which is no longer just descriptive or estimative and starts to guide structured decisions in the logistics context.

In addition, the application of advanced predictive analytics in inventory management has contributed to the refinement of decision-making processes. Murray et al. (2023) point out that the use of more robust analytical models enables more accurate management of inventory levels, reducing waste and improving customer service. These models operate based on real-time data, which favors continuous adjustments and greater adherence to market conditions.

Finally, the incorporation of predictive systems into logistics also involves the ability to monitor and correct operational failures in an automated way. Causin (2021) observes that the artificial intelligence systems used in Logistics 4.0 not only anticipate problems, but also indicate corrective actions, contributing to the continuity and stability of operations. This approach reinforces the strategic role of artificial intelligence in supply management, consolidating its use as an integral part of contemporary logistics practices.

3.2 ARTIFICIAL INTELLIGENCE IN DEMAND FORECASTING AND PROCUREMENT OPTIMIZATION

Demand forecasting through artificial intelligence has generated a profound and significant transformation in the way companies structure and organize their procurement processes and the logistics planning they carry out. This change is not only modifying strategies, but also the way these activities are carried out, which affects the internal dynamics and agility of companies in meeting market demands. In the context of Logistics 4.0, it is already possible to observe the application of advanced analytical models, which are capable of processing large volumes of data and generating much more reliable forecasts. This technological evolution plays a crucial role in reducing operational uncertainties, making the logistics environment more stable and efficient. According to Intermodal (2026), models that use machine learning techniques are able to detect various consumption patterns and can also predict changes in demand more accurately and efficiently. This methodology offers a detailed analysis that helps to understand and manage variations in consumer behavior in the market. In this scenario, Table 2 presents a systematization of the main predictive models applied to logistics.

Table 2

Predictive Models Applied to Logistics

Model	Description
Linear regression	"simple and interpretable, for linear relationships between variables and demand";
ARIMA	"effective for time series with seasonality and linear trends";
Decision trees	"interpretable, they capture non-linear interactions";
Random Forest	"robustness and reduction of overfitting with multiple decision trees";
Gradient Boosting Machines (GBM)	"high accuracy, ideal for tabular data";
Support Vector Machines (SVM)	"effective for high-dimensional and nonlinear data";
Artificial Neural Networks (ANN)	"capture complex relationships in large data sets";
Recurrent neural networks (RNN) and LSTMs	"ideal for sequential data and time series";
Convolutional neural networks (CNN)	"applicable to time series to capture local patterns";
Prophet	"developed by Meta, handles seasonal components and irregular events well";
Temporal Convolutional Networks (TCN)	"capture long-term dependencies on temporal data";
XGBoost	"efficient gradient boosting often outperforms other algorithms";
Stacking	"combines multiple models to improve forecast accuracy";
Model Combination	"uses the strengths of different methods, such as combining ARIMA for seasonal patterns with neural networks for nonlinear relationships."

Source: INTERMODAL (2026).

The use of these models improves procurement planning by aligning procurement volumes with real market demands. According to Souza et al. (2026), artificial intelligence in the procurement process increases the analytical capacity of companies, leading to more informed choices in the selection of suppliers, the definition of quantities, and the management of contracts. This minimizes errors caused by inadequate forecasts and increases synergy between key areas.

In addition, the literature shows that using predictive algorithms in demand forecasting results in significant operational gains. Rustice et al. (2024) indicate that the application of artificial intelligence tools in logistics makes it possible to optimize processes, reduce costs, and improve the performance of supply chains as a whole. In this scenario, demand forecasting is no longer a mere exercise based on data from the past, but rather a tool that takes into account real-time variables, increasing the agility of companies.

With regard to demand planning, both Senhori and Gottardo (2023) and Julianelli (2023) point out that machine learning models increase the accuracy of forecasts, especially in volatile and seasonal contexts. According to these authors, the fusion of historical data, external variables, and sophisticated algorithms results in more informed decisions.

Table 3

AI and ML-Based Solutions for Monitoring and Tracking

Solution	Description
IoT devices	"IoT sensors installed in goods and vehicles collect real-time data, such as GPS location, temperature, humidity, and handling conditions";
Sensor Networks	"transmit data continuously to central systems, allowing constant monitoring of the conditions and location of assets";
IoT integration	"TMS systems integrate data from IoT sensors to provide real-time visibility into the status and location of goods during transportation";
Predictive analytics	"use ML algorithms to predict delays, optimize routes, and improve transportation efficiency";
Software Platforms	"platforms like Luft Digital offer end-to-end visibility, tracking shipments in real-time and providing continuous updates on the status of goods, occurrences, and even POD (proof of delivery)";
Alerts and notifications	"platforms send proactive alerts about delays, route deviations or inadequate conditions, allowing companies to respond quickly to problems";
Integration with RFID devices, barcodes and IoT sensors	"used to track the location and movement of items within the warehouse in real time";
Inventory Optimization	"ML algorithms analyze inventory data to optimize product disposition, reduce search times, and improve operational efficiency";
Route optimization	"analyze real-time data on traffic, weather conditions and transport restrictions, optimizing routes for faster and more efficient deliveries";
Data analysis	"advanced analytics tools that use ML to process large volumes of supply chain data, identifying patterns and anomalies";

Solution	Description
Demand and inventory forecasting	"predictive models that help predict future demand and adjust inventory levels in real time, avoiding excess or lack of products";
Last mile optimization	"platforms that use AI to optimize last-mile deliveries, considering factors such as customer locations, time windows, and delivery preferences";
Delivery tracking	"mobile apps, such as Luft Delivery, and real-time tracking systems that allow customers to track the status and location of their deliveries."

Source: INTERMODAL (2026).

The integration and use of these technologies demonstrate that artificial intelligence goes beyond its previous limitations, which focused only on demand forecasting, as now its application extends, in a significant way, to the real-time monitoring of operations and the integrated management of logistics activities in a more efficient and complete way. Artificial intelligence, according to Toledo and Camargo Filho (2025), has been one of the main responsible for influencing purchasing decisions, as it advances and is applied. This impact is especially evident in e-commerce, where technology has facilitated a more agile buying process that is adapted to consumer preferences and behaviors. Thus, artificial intelligence not only simplifies transactions but also adjusts to the needs and habits of users, making the shopping experience more efficient and enjoyable. The interconnection between forecasting and monitoring with logistics execution, without a doubt, strengthens a management model based on real data. This model brings greater operational transparency and, consequently, improves the efficiency of the purchasing processes and availability of products in the market. When these components are connected, a constant flow of information and faster decisions are ensured, resulting in a significant improvement in inventory management and customer satisfaction.

3.3 DATA-DRIVEN INVENTORY MANAGEMENT AND LOGISTICS EFFICIENCY

Data-based inventory management has established itself as one of the transformative axes of logistics operations, especially by integrating artificial intelligence techniques. In this sense, the use of automatic systems enables a more effective control of inventory levels, minimizing the uncertainties caused by demand variation. In e-commerce, process automation, enabled by artificial intelligence, leads to more assertive decisions about replenishment and inventory control, according to Freitas (2024).

The use of predictive models also transforms the way companies balance excess and stockouts. Peterson (2021) states that artificial intelligence is capable of predicting consumption trends based on past data and context variables, helping to keep inventories at optimal levels. This results in lower storage operating costs and increased product availability for the end consumer.

In analytical terms, the international literature has shown consistent progress in the implementation of artificial intelligence in inventory management. According to Albayrak Ünal et al. (2023), in a systematic review, machine learning algorithms have been used, in general, to predict demands, optimize inventory levels, and assist in strategic decision-making. These models increase data processing power and enable more detailed analysis, which results in greater efficiency in logistics operations.

Inventory forecasting, driven by artificial intelligence, becomes crucial for the coordination of supply chains in e-commerce. According to Çayli and Oralhan (2024), systems based on artificial intelligence enable more agile decision-making that is in tune with market fluctuations, especially in contexts of high volatility. These models are able to minimize operational failures and improve logistics performance comprehensively.

In addition, the use of artificial intelligence in warehousing operations has generated significant increases in operational efficiency. Favaro (2023) highlights that the use of sophisticated algorithms makes it possible to optimize the arrangement of products, minimize movement times, and make better use of physical space. These improvements have a direct effect on the productivity of operations and promote more integrated inventory management.

Finally, the use of artificial intelligence solutions for inventory management has increased the ability of companies to deal with demands that are, by nature, dynamic and complex. According to Gemniczak et al. (2025), the adoption of these technologies results in decreased logistics costs, increased accuracy of forecasts, and greater efficiency in processes. Thus, data-driven inventory management becomes a pillar of today's logistics efficiency.

4 FINAL CONSIDERATIONS

The use of predictive models with artificial intelligence in the management of purchases, inventories, and demands is transforming modern logistics, especially in organizations that need more agility in decisions and more detailed analysis. The growing availability of data, combined with the improvement of computational techniques, has enabled companies to create more integrated and evidence-based processes, which increases the consistency of operations and reduces uncertainties related to market dynamics.

In view of the analysis carried out, it is found that the research fully complied with what was proposed by investigating, in an articulated way, the theoretical aspects and practical applications of predictive models in logistics. Therefore, the general objective was achieved by exposing how artificial intelligence collaborates with the improvement of logistics processes and

the strengthening of managerial decision-making. Likewise, the specific objectives were fulfilled throughout the sections that form the theoretical foundation.

Regarding the first topic of the theoretical foundation, the research showed that the fundamentals of predictive models and artificial intelligence in logistics are anchored in analytical techniques capable of processing large volumes of data and identifying relevant patterns for scenario prediction. These models expand the ability of organizations to anticipate demands and adjust operations more consistently. Regarding the second topic, it was observed that the application of artificial intelligence in demand forecasting and purchase planning contributes to decisions more aligned with market needs, reducing estimation errors and promoting a greater balance between supply and demand. In the third topic, it was found that data-driven inventory management favors the reduction of operating costs, avoids both excesses and stockouts, and contributes to logistics efficiency, by allowing greater control and precision in the management of inventory levels.

A development that occurs naturally from this study is the recommendation for more empirical studies, especially focused on the application of predictive models in different segments of the economy. This expansion of studies is crucial to deepen and enrich the understanding of the effects that these models can cause in organizational contexts that are, by their nature, diverse and distinct. Therefore, it is hoped that these studies will help to elucidate the effectiveness and impact of predictive models in various work environments and sectors of the economy. In addition, it is pertinent and opportune to deepen the comparisons between the artificial intelligence techniques that were analyzed. It is important that this study also thoroughly evaluates the impacts that these techniques may have in specific management and administration contexts. Also investigate the interaction and synergy between predictive systems and the new technologies that are emerging, as this union can accelerate and favor the advancement of understanding about digital transformation processes in the logistics sector.

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CIVILIZATIONAL TRANSITION AND SPIRITUAL INTELLIGENCE: A SYSTEMIC ANALYSIS OF CONTEMPORARY SOCIO-STRUCTURAL CHALLENGES

TRANSIÇÃO CIVILIZATÓRIA E INTELIGÊNCIA ESPIRITUAL: UMA ANÁLISE SISTÊMICA DOS DESAFIOS SOCIOESTRUTURAIS CONTEMPORÂNEOS

TRANSICIÓN CIVILIZATORIA E INTELIGENCIA ESPIRITUAL: UN ANÁLISIS SISTÉMICO DE LOS DESAFÍOS SOCIOESTRUTURALES CONTEMPORÁNEOS



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ABSTRACT

The article proposes that humanity is undergoing a civilizational transition in which geopolitical and health crises act as catalysts for overcoming an anthropocentric and unequal model. It is argued that exacerbated individualism and predatory exploitation have reached their limits, revealing the collapse of structures that prioritize competition over cooperation. The solution lies in Spiritual Intelligence (SQ), a capacity that enables individuals to reframe suffering and act as agents of ethical transformation. From a systemic perspective, society is described as an interdependent organism; therefore, environmental balance and social justice are inseparable from inner reform. The text emphasizes the ethics of otherness and humility as pillars of a new paradigm, urging conduct guided by sustainability and compassion to ensure survival in the Anthropocene and collective moral evolution.

Keywords: Civilizational Transition. Spiritual Intelligence. Systemic Interdependence. Ethics of Otherness. Planetary Sustainability.

RESUMO

O artigo propõe que a humanidade atravessa uma transição civilizatória, onde crises geopolíticas e sanitárias atuam como catalisadores para a superação de um modelo antropocêntrico e desigual. Argumenta-se que o individualismo exacerbado e a exploração predatória atingiram seu limite, evidenciando a falência de estruturas que priorizam a competição em detrimento da cooperação. A solução reside na Inteligência Espiritual (QS), capacidade que permite ao indivíduo ressignificar a dor e agir como agente de mudança ética. Sob uma visão sistêmica, a sociedade é descrita como um organismo interdependente; logo, o equilíbrio ambiental e a justiça social são indissociáveis da reforma íntima. O texto enfatiza a ética da alteridade e a humildade como pilares para um novo paradigma, urgindo por uma conduta pautada na sustentabilidade e na compaixão para garantir a sobrevivência no Antropoceno e a evolução moral coletiva.

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Palavras-chave: Transição Civilizatória. Inteligência Espiritual. Interdependência Sistêmica. Ética da Alteridade. Sustentabilidade Planetária.

RESUMEN

El artículo propone que la humanidad atraviesa una transición civilizatoria en la que las crisis geopolíticas y sanitarias actúan como catalizadores para superar un modelo antropocéntrico y desigual. Se argumenta que el individualismo exacerbado y la explotación depredadora han alcanzado su límite, evidenciando el colapso de estructuras que priorizan la competencia en detrimento de la cooperación. La solución reside en la Inteligencia Espiritual (IE), capacidad que permite al individuo resignificar el dolor y actuar como agente de transformación ética. Desde una visión sistémica, la sociedad es descrita como un organismo interdependiente; por lo tanto, el equilibrio ambiental y la justicia social son inseparables de la reforma interior. El texto enfatiza la ética de la alteridad y la humildad como pilares de un nuevo paradigma, instando a una conducta guiada por la sostenibilidad y la compasión para garantizar la supervivencia en el Antropoceno y la evolución moral colectiva.

Palabras clave: Transición Civilizatoria. Inteligencia Espiritual. Interdependencia Sistémica. Ética de la Alteridad. Sostenibilidad Planetaria.

1 INTRODUCTION: THE CRISIS AS A CATALYST FOR CHANGE.

This reflection proposes an analysis of the lessons arising from socio-structural conflicts, understanding the current scenario as a period of civilizational transition. This historical interval is characterized by deep socio-structural antitheses, which have been intensely evidenced and catalyzed by the global geopolitical crisis.

It is observed, primarily, the persistence of an anthropocentric and hierarchical paradigm, in which the belief in human supremacy over the ecosystem is replicated in interpersonal relationships, manifesting itself in forms of domination based on gender, race, color and nationality. Such structural prejudices fuel latent conflicts that prevent the consolidation of a perennial global peace.

In the economic sphere, the indicators reveal a critical conjuncture: paradoxically to technological advances, we currently observe the emergence of hundreds of millions of new individuals in situations of extreme vulnerability. The geographical disparity accentuates this imbalance, evidencing a nutritional and developmental dichotomy between the Northern Hemisphere — marked by pathologies resulting from overconsumption — and the Southern Hemisphere, notably the African continent, which faces serious subsistence crises.

Data from Credit Suisse's *global wealth report* (2021) corroborate the magnitude of this inequality, indicating that only 1% of the world's population (the stratum of billionaires) holds about 46% of accumulated global wealth. This concentration of capital is reflected locally in the coexistence of opulence and pockets of abject poverty. Ultimately, the contemporary scenario exposes the failure of a model of exacerbated individualism, highlighting the urgency of a transition to thoughts and policies of a collective and integrating nature.

2 SYSTEMIC INTERDEPENDENCE: FROM INDIVIDUALISM TO THE SOCIAL ORGANISM

The universality of suffering imposed by the contemporary crisis requires a review of ethical conduct and the understanding of humanity as an integrated and interdependent system. From a sociological and systemic perspective, the individual must be understood as a constituent unit of a collective social organism, in which the commitment of one of its parts inevitably has repercussions on the system as a whole. This interconnection is not limited to interpersonal relationships, but extends in a visceral way to the ecosystem balance, involving fauna, flora, and the environment as indispensable variables for human survival.

However, an intrinsic duality is observed in human agency. The same subject capable of ecocentric and unethical behaviors — promoters of exclusion and inequality — holds the potential for the mobilization of virtues such as altruism, a sense of justice, and creativity in

favor of social progress. This dichotomy suggests that social pathologies are not merely exogenous; Often, human behavior itself acts as the vector for "illness" in relationships. Consequently, the resolution of global crises lies less in external interventions and more in the ethical reorientation of human behavior.

The severe social isolation resulting from the management of the pandemic, for example, acted as a forced psychosocial experiment, exposing the fragility of pre-existing relational structures. The statistical increase in the rates of marital dissolution, generational conflicts, and the alarming growth in suicide rates and mental disorders show a crisis of adaptation and psychological support.

Furthermore, the period revealed a transfer of pedagogical responsibility: the excessive dependence of school institutions for the mediation of the basic education of children became evident when families were compelled to live together uninterruptedly. In short, the pandemic scenario not only tested the biological resilience of the species, but also worked as a catalyst for reflection on the need for a more robust collective conscience and mental health based on the quality of human bonds.

3 EPISTEMOLOGICAL ANALYSIS OF COLLECTIVE SCOURGES AND THE LAW OF PROGRESS

The understanding of war conflicts and other collective scourges requires an analysis that transcends instincts, entering the field of natural laws and human moral development. From this perspective, such events are configured as mechanisms of improvement, which impel the individual to exercise intelligence, resilience and otherness. The crisis acts, therefore, as a catalyst for virtues such as self-denial and love of neighbor, counteracting the tendencies of selfishness and vanity that often stagnate social progress.

The interpretation of these phenomena is based on the understanding of a law of cause and effect, of a universal and ethical nature. According to this principle, for every imbalance or abuse committed — whether through ignorance or deliberation — a proportional correction is manifested in the opposite direction. Such failures, although committed individually, often aggregate in collective dimensions, involving families, peoples and entire populations. Consequently, the ethical infractions of a society in relation to its environment and its fellow human beings require reparation supported by the same natural legislation that governs life.

The destructive scourges are, therefore, reflections of this corrective dynamic. As we have been taught in spiritual traditions, the perception of "evil" or "harm" is due to a strictly personal and immediate vision. From the perspective of the Law of Progress, such upheavals

are necessary instruments to accelerate the transition to a higher social order, allowing moral and organizational advances, which would take centuries, to be consolidated in a few years.

The contemporary scenario reflects the past actions of man in relation to the environment and relational structures. When projecting the post-pandemic period, it was observed that the notion of a "return to normality" was conceptually fragile, since the previous model of life proved to be dysfunctional. History, marked by events such as the Black Death and the Spanish Flu, reiterates that renewal is an evolutionary constant. In the face of the impact of the current crisis, the central issue shifts from mere biological survival to the need to open new ethical paths, fundamental for the construction of a new global reality.

4 SPIRITUAL INTELLIGENCE AS A PATH TO RESILIENCE AND COMPASSION

In the face of the deep humanitarian and political crisis that characterizes contemporaneity – manifested in warlike conflicts, geopolitical instabilities and collective tragedies – the need to identify ways to build a new global paradigm is imposed. The search for a transformed world requires a holistic understanding of the difficulties faced, based not only on technical solutions, but on a profound ethical and moral reform.

In this context, Danah Zohar's work on Spiritual Intelligence (QS) offers a relevant theoretical basis. QS is defined as the human ability to give meaning and value to actions, allowing the individual to transcend the condition of victim of circumstances to become an active agent of change. The transformation of the social structure depends intrinsically on the modification of the units that compose it: the individual. By reorienting personal values, the subject alters the family microenvironment and, consequently, the macrostructural relations in his community, acting as a vector of moral regeneration.

The recent health crisis and the imposed social isolation and the current belligerent litigation have served as catalysts for this reflection. The distancing from affections and the vulnerability of risk groups showed that collective challenges are opportunities for the exercise of resilience and the review of priorities. The civilizational ideal lies in the transition from a self-centered love to a conscious altruism, although it is observed that a majority of the global population has not yet awakened to this need for systemic cooperation.

Unlike the logic of classical natural selection, which favors competition and the survival of the fittest, the evolution of human relations in the twenty-first century points to cooperation as a requirement for sustainability. Achieving common global goals requires a synergy that eliminates predatory competition between nations and individuals. Viktor Frankl corroborates this thesis by stating that the perception of meaning in life is linked to mutual utility. Human

survival is essentially a process of interdependence: the modern individual is sustained by an invisible network of other people's labor, which provides everything from food subsistence to the technological apparatus.

Therefore, overcoming existential emptiness, which often leads to despair in moments of social conflict, depends on the discovery of a higher purpose. Self-discovery and epistemological humility are essential tools in this process. Recognizing oneself as an integral part of a complex system requires the acceptance of otherness and the multiplicity of perspectives. Just as visual perception phenomena admit different interpretations, social and moral realities demand the understanding that there are several legitimate points of view, with humility being the only path to peaceful coexistence and humanitarian integration.

5 THE ETHICS OF ALTERITY AND THE PHENOMENOLOGY OF THE NOW IN SPIRITUAL INTELLIGENCE

The development of humility in all spheres of existence is a fundamental pillar for the health of human relationships and collective progress. From the perspective of Spiritual Intelligence, it is understood that knowledge is not a static or hierarchical structure; on the contrary, it is a dynamic system of exchange. In the social fabric, the contribution of each individual — regardless of his or her technical function or socioeconomic *status* — has intrinsic value. The exchange of experiences in community reveals that wisdom is omnipresent: both the holder of high academic degrees and the operational worker have knowledge that, when integrated, promotes the evolution of the group.

The main obstacle to this integration is the persistence of egocentric traits, such as pride and vanity. Such characteristics are counterposed by the principles of Christian ethics, which, interpreted as a treatise on humanistic psychology, points to humility as the basis of blessedness and balance. The historical figure of Christ exemplifies the reversal of traditional power paradigms: while the logic of the physical plane reveres authority based on command and subordination, spiritual ethics proposes that true greatness lies in the attitude of service. The transition from "I" to "we" requires the overcoming of manipulative behaviors, whether conscious or unconscious, in favor of a conduct based on social utility and cooperation.

With regard to temporal perception, the existential mistake of inhabiting anachronistic dimensions is observed: guilt associated with the past and anxiety projected into a hypothetical future. Spiritual Intelligence advocates valuing the present moment as the only viable space for action and transformation. The past must be re-signified as a process of learning through trial and error, devoid of punitive burdens, while the future is understood as a construction resulting

from immediate choices. This "conscious presence" allows the individual to take responsibility for building his own destiny.

Furthermore, the intrinsic connection between beings and the environment emphasizes individual responsibility over the collective psychosphere. According to the principles of Zohar, the emotional and ethical state of the individual directly affects the network of connections in which he is inserted. States of negativity or hope are not isolated; they spread and contaminate or elevate the work environment and the family nucleus.

The search for truth requires a critical and investigative posture in the face of the saturation of contemporary information. The passive acceptance of digital narratives without due intellectual questioning compromises the integrity of knowledge. Autonomous thinking, supported by research and diligent study, is the essential requirement for the awakening of consciousness and for the consolidation of a society based on real and verifiable values.

6 INTELLECTUAL ETHICS, EXISTENTIAL PURPOSE, AND THE PHENOMENOLOGY OF COMPASSION

The maintenance of ethical and intellectual principles must be dissociated from arrogance, behavior that proves to be particularly deleterious in the political environment. Erudition and eloquence, when used as instruments of superiority, often act as defense mechanisms to hide vulnerabilities and uncertainties intrinsic to the subject. From the perspective of Spiritual Intelligence, intellectual maturity is manifested in the celebration of diversity and in the acceptance of otherness without a priori value judgments. Diplomatic dialectics must prioritize the debate of ideas and ideals to the detriment of personal disqualification, recognizing the limitation of human judgment, which is invariably partial because it does not know the totality of the existential trajectory of the other.

The investigation of the purpose of life and the individual vocation is an imperative for overcoming mass behavior and social conformity. The relevance of an ideal is measured by the resilience and equanimity demonstrated by its proponents in the face of adversity. Historically, the introduction of disruptive paradigms has been accompanied by resistance and social stigma. Notable examples include Giordano Bruno, whose cosmological model challenged geocentrism; James Watt, whose steam technology was initially underestimated; and Horace Wells, who faced skepticism from the medical community by proposing the feasibility of anesthesia. Such trajectories demonstrate that scientific and social progress often requires personal sacrifice for the sake of an ulterior collective benefit.

In this sense, the experience of compassion — understood etymologically as the ability to internalize the pain of others — is established as the foundation of a new planetary consciousness. The practice of humility, exemplified by the self-perception of one's own finitude in the face of the magnitude of the cosmos, is essential to mitigate the anthropocentric vision that subordinates nature and animals to human interests.

The consolidation of this new paradigm requires a revolution in contemporary thought, transcending the political sphere and reaching the educational base. The insertion of philosophy in the curricula of elementary and secondary education presents itself as a fundamental pedagogical strategy for the development of individuals capable of valuing others and understanding the power of the mind in the construction of an integrated and ethical reality.

7 PLANETARY SUSTAINABILITY AND THE ETHICS OF HUMAN CONDUCT: AN EVOLUTIONARY SYNTHESIS

The understanding that human existence occurs in a global community system imposes the imperative need for environmental preservation. Since the Rio+20 conference, the global agenda has been guided by the 17 Sustainable Development Goals (SDGs), which aim to eradicate poverty and biospheric protection by 2030. In the current stage, called the Anthropocene, human activity has altered the geological and biological balance of the Earth in a century more drastically than in the last four millennia.

According to researcher Johan Rockström, humanity has already exceeded several of the nine Planetary Boundaries, including biodiversity loss and ocean acidification. In this context, the law of action and reaction manifests itself as a systemic correction to environmental abuses. An effective response to this scenario lies in changing consumption patterns, specifically in the transition to plant-based diets. The production of animal protein is responsible for the massive emission of methane and the disproportionate consumption of water and territorial resources. The adoption of vegetarianism is, therefore, presented as a strategy of double efficacy: it mitigates environmental degradation and acts in the prophylaxis of chronic non-communicable diseases.

The lessons we must draw from the current crisis need to transcend the economic sphere, challenging society to modernize interpersonal relationships and humanize the very spirit of collectivity. The centrality of the problem lies in human conduct; As Socratic thought postulates, the negative consequences we reap are the result of the causes we plant. Moral virtue, in this perspective, is understood as a consequence of habit. The individual and collective

character is consolidated through the repetition of just and courageous acts, making conduct the main determinant of human destiny.

Regarding the challenge of maintaining humility in a competitive and self-centered global environment, Spiritual Intelligence suggests that arrogance functions as a psychological compensation for inferiority complexes. Overcoming this state requires the recognition of otherness — seeing one's neighbor as a peer. Tools such as meditation and mindful consumption help develop compassion and reduce human reactivity.

The transition to a more just and compassionate world resembles historical processes of generational renewal: just as new generations inherit and transform cultural values, today's children grow up under a new environmental and social ethic. Although religion acts as a mediating social experience, the ultimate goal must be the modification of the individual moral core. The preservation of the environment for future generations requires more than superficial actions; It demands a deep awareness of the impact of daily habits. The conclusion of this study reiterates that human evolution is inseparable from the practice of love, the continuous search for knowledge, and the understanding that systemic justice governs all phenomena of life.

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**BETWEEN MEMORY, ALTERITY, AND FORM: REFLECTIONS ON THE
TRANSLATION PROCESS OF SOLO QUEDA SALTAR (2018), BY MARÍA
ROSA LOJO, INTO BRAZILIAN PORTUGUESE**

**ENTRE MEMÓRIA, ALTERIDADE E FORMA: REFLEXÕES SOBRE O
PROCESSO DE TRADUÇÃO DE SOLO QUEDA SALTAR (2018), DE MARÍA
ROSA LOJO, PARA O PORTUGUÊS BRASILEIRO**

**ENTRE MEMORIA, ALTERIDAD Y FORMA: REFLEXIONES SOBRE EL
PROCESO DE TRADUCCIÓN DE SOLO QUEDA SALTAR (2018), DE MARÍA
ROSA LOJO, AL PORTUGUÉS BRASILEÑO**



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ABSTRACT

This article analyzes the process of translating into Portuguese the novel *Solo queda saltar* (2018), by María Rosa Lojo, which has not yet been published in Portuguese within the Brazilian literary system, from a perspective that articulates ethics, form, and cultural mediation. Grounded in the contributions of Antoine Berman (2007), Lawrence Venuti (2008), Gideon Toury (1995), and Eugene Nida (1964), the study discusses the construction of a translation project oriented toward preserving alterity, the plurality of narrative voices, and the formal density of the source text. The adopted methodology integrates hermeneutic reading, stylistic analysis, and systematic recording of translation decisions throughout the process, configuring a practice-based approach. Based on the analysis of concrete choices—such as the translation of the title, the treatment of temporal regimes, and the use of paratextual resources—the study examines dilemmas, losses, and mediation strategies involved in transferring the novel into Portuguese. It argues that literary translation, understood as an interpretative, ethical, and situated practice, also constitutes a form of knowledge production. The study thus contributes to the debate on translational authorship, applied methodology, and translation as rewriting within the Brazilian context.

Keywords: Literary Translation. Translation Process. Memorial Novel. Memory. Alterity. María Rosa Lojo.

RESUMO

Este artigo analisa o processo de tradução para o português do romance *Solo queda saltar* (2018), de María Rosa Lojo, ainda sem tradução para o português publicada no sistema literário brasileiro, a partir de uma perspectiva que articula ética, forma e mediação cultural. Fundamentado nas contribuições de Berman (2007), Venuti (2008), Toury (1995) e Nida

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(1964), o estudo discute a construção de um projeto tradutório orientado pela preservação da alteridade, da pluralidade de vozes narrativas e da densidade formal do texto-fonte. A metodologia adotada integra leitura hermenêutica, análise estilística e registro sistemático das decisões tradutórias ao longo do processo, configurando uma abordagem baseada na prática. A partir da análise de escolhas concretas — como a tradução do título, o tratamento dos regimes temporais e o uso de recursos paratextuais —, examinam-se dilemas, perdas e estratégias de mediação envolvidos na transposição do romance para o português. Argumenta-se que a tradução literária, compreendida como prática interpretativa, ética e situada, constitui também uma forma de produção de conhecimento. O estudo contribui, assim, para o debate sobre autoria tradutória, metodologia aplicada e tradução como reescrita para o contexto brasileiro.

Palavras-chave: Tradução Literária. Processo Tradutório. Romance Memorial. Memória. Alteridade. Maria Rosa Lojo.

RESUMEN

Este artículo analiza el proceso de traducción al portugués de la novela Solo queda saltar (2018), de María Rosa Lojo, aún sin traducción publicada en el sistema literario brasileño, a partir de una perspectiva que articula ética, forma y mediación cultural. Fundamentado en los aportes de Antoine Berman (2007), Lawrence Venuti (2008), Gideon Toury (1995) y Eugene Nida (1964), el estudio discute la construcción de un proyecto traductor orientado a la preservación de la alteridad, de la pluralidad de voces narrativas y de la densidad formal del texto fuente. La metodología adoptada integra lectura hermenéutica, análisis estilístico y registro sistemático de las decisiones traductorales a lo largo del proceso, configurando un enfoque basado en la práctica. A partir del análisis de elecciones concretas —como la traducción del título, el tratamiento de los regímenes temporales y el uso de recursos paratextuales—, se examinan dilemas, pérdidas y estrategias de mediación involucradas en la transposición de la novela al portugués. Se argumenta que la traducción literaria, comprendida como una práctica interpretativa, ética y situada, constituye también una forma de producción de conocimiento. El estudio contribuye, así, al debate sobre la autoría traductora, la metodología aplicada y la traducción como reescritura en el contexto brasileño.

Palabras clave: Traducción Literaria. Proceso Traductor. Novela Memorial. Memoria. Alteridad. María Rosa Lojo.

1 INTRODUCTION

Literary translation is configured as a complex practice in which linguistic, aesthetic, historical and ethical dimensions are articulated. Unlike other translation modalities, its object is not limited to the transmission of informational content, but involves the recreation of forms, rhythms, voices, and effects of meaning that constitute the text as a literary work. In this sense, as Berman (2007, p. 17) states, "translation is an experience of alterity", insofar as it implies an ethical confrontation with the foreigner and with the materiality of the other's language. Translating literature, therefore, does not consist only of transposing meanings, but of assuming a reflective position in front of the source text, recognizing that every translation is crossed by choices, losses and negotiations.

The translation experience, in the meantime, implies a work of attentive listening to the materiality of the text, guided by the refusal of the so-called "deforming tendencies" (Berman, 2007, p. 48), which tend to domesticate the foreigner and neutralize its formal singularity. This perspective finds resonance in the reflections of Venuti (2008, p. 15-20), for whom the excessive search for fluency and the consequent invisibilization of the translator contribute to the systematic erasure of cultural alterity in the receiving literary system. In this sense, both are focused on the ethical dimension of translation, understood as a practice that involves choices in the face of the linguistic and cultural Other.

However, by situating such choices within concrete literary systems, one cannot disregard the role of institutional norms and expectations that condition translation behavior. This is because, as Toury (1995, p. 56) observes, all translation is carried out under the influence of norms operating in the receiving system, which guide decisions regarding acceptability and adequacy. In this way, the translator works in a field tensioned between ethical principles and systemic conditioning, where it becomes necessary to seek instruments to think about the pragmatic, emotional and affective effects of the translated text on the reader and his or her cultural community. In this process, it is necessary to emphasize that, although the notion of dynamic equivalence must be mobilized in a critical way when applied to literary translation, the formal density of the source work cannot be reduced to the production of immediate communicative effects.

From this perspective, this article aims to scrutinize the production of the translation project into Portuguese of the novel *Solo queda salto* (2018), by María Rosa Lojo, a work still unpublished in the Brazilian literary system. Taken as a memorial novel, this narrative mobilizes specific discursive procedures, in which testimony, silence and temporal fragmentation play a central role, bringing unique challenges to translation, especially with regard to the preservation

of the rhythm, significant opacity and ethical dimension of the story. Built from the articulation between individual memory, collective history and migratory experience, through female voices marked by affective restraint and reflective density, the work requires the formulation of a translation project capable of preserving the memorialistic voice, historical density and stylistic restraint, without resorting to excessive domestication or the neutralization of the marks of otherness.

For this reason, this study investigates the registration, analysis and justifications in the face of the decisions made throughout the translation process, transforming it into an object of systematic and conceptual reflection. Thus, it seeks not only to present results, but to explain the methodological path that supports the choices made.

To this end, the process of translation of the novel is critically analyzed, emphasizing the dilemmas, strategies and negotiations involved in the passage of the text from Spanish to Portuguese. More specifically, it seeks to: (a) describe the construction of the translation project adopted; (b) examine decisions related to voice, rhythm, syntax, metaphors and cultural references; (c) to discuss the limits and potentialities of the theoretical categories mobilized in the face of a concrete corpus; and (d) to reflect on translation authorship as a mediating practice between languages, cultures and temporalities.

From the methodological point of view, the study adopts a qualitative and reflective approach, based on the hermeneutic reading of the source text, on the stylistic analysis and on the systematic recording of translation decisions throughout the process. In line with proposals that defend practice-based research, this procedure articulates stages of interpretation, experimentation, revision and critical evaluation, configuring a path in which translation and investigation interpenetrate. The analysis is based on selected excerpts from the novel, confronted with their respective solutions in Portuguese, in order to highlight the criteria that guided the choices made.

Thus, by making visible the stages, impasses and decisions involved, the article seeks, in a parallel way, to contribute to the debate on the devices that articulate and shape literary networks and communities contemporaneously, showing, as Venuti (2008, p. 1-5) points out, the role of the translator as a cultural agent.

2 ETHICS, ALTERITY AND MEDIATION IN LITERARY TRANSLATION: THE QUESTION OF TRANSLATOR'S VISIBILITY, FOREIGNIZATION AND CULTURAL RESPONSIBILITY

Based on the assumption that literary translation is an interpretative, historically and ethically situated practice – also crossed by aesthetic and political relational dimensions –

Berman (2007) confronts the translator with the challenge of welcoming the text of the Other without reducing it to the standards of the target culture. This experience is not restricted only to the thematic level, but is manifested in the relationship with the materiality of the language, with the rhythm, syntax and discursive organization of the source text.

By systematically criticizing translation practices that tend to erase this otherness through processes of normalization and excessive adaptation, Berman (2007, p. 48–72) identifies a set of "deforming tendencies", such as rationalization, clarification, embellishment, and homogenization, which operate in the sense of domesticating the foreign text. These tendencies, often naturalized, produce translations that are formally correct, but impoverished from an aesthetic and cultural point of view. For this reason, in proposing an "ethics of translation", Berman does not advocate a mechanical literalism, but a rigorous attention to what he calls the "letter" of the text. This notion refers to the singular articulation between form and meaning, to the materiality of language and to the author's stylistic choices. Translating according to the letter implies, therefore, preserving the productive strangeness of the text, its irregularities, its silences and its zones of opacity.

This perspective guides, therefore, a systematic refusal of excessive rationalization and stylistic simplification, conceiving translation as a practice of listening, in which the translator places himself in a position of openness in the face of textual alterity. In this sense, the mediating role of the translator and his centrality in the process of circulation of the work are evidenced. Translation is thus configured as a space of mediation between languages, cultures, temporalities and reading regimes, in which the translator assumes the responsibility of negotiating differences without neutralizing them. Far from functioning as a neutral instance, this mediation involves interpretative choices, ethical positions and contextual evaluations, which situate the translated text within a specific literary system. In this way, the ethics of alterity proposed by Berman (2007) is articulated with a conception of critical mediation, in which the preservation of the singularity of the source text is combined with the construction of conditions of legibility in the culture of arrival.

In this context, by situating translation within power relations and cultural asymmetries, the dominant tradition in literary systems privileges fluency as a supreme value, producing translations that "give the illusion of transparency" (Venuti, 2008, p. 01) and hide the translator's work. This ideal of transparency – associated with what the author calls "translator's invisibility" – constitutes a phenomenon in which translation is presented as a text originally written in the target language, erasing its condition of cultural mediation. This practice, however, contributes to the domestication of the foreigner and to the reproduction of cultural hierarchies. For this

reason, Venuti proposes strategies of foreignization, understood as ways of inscribing marks of its linguistic and cultural otherness in the translated text. Foreignization does not aim at the exoticization of the text, but at the production of a displacement effect that invites the reader to recognize the difference. It is, therefore, an ethical and political stance, which attributes to the translator the role of cultural agent.

This notion, however, must be mobilized in a critical and contextualized way, so as to avoid both the systematic neutralization of the historical, geographical, and discursive marks of the novel and the transformation of foreignization into an empty formal procedure. As Venuti himself warns (2008, p. 18-20), the visibility of the translator is not to be confused with the subjective display of his presence in the text, but with the explicitness of the cultural and ideological conditions that cross the translation.

In this sense, visibility manifests itself less as a self-referential mark of the translator and more as an interpretative responsibility towards the work, the reader and the literary system of arrival. It is a matter of making the mediating character of translation perceptible, without shifting the focus from the aesthetic experience of the text. The translator's performance, therefore, is not guided by the affirmation of an autonomous individual voice, but by the conscious construction of a space for dialogue between cultures, temporalities and regimes of meaning.

In this way, foreignization, understood as an ethical strategy, does not imply an artificial rupture with the norms of legibility, but a critical negotiation with them. The visibility of the translator is configured, therefore, as a mediating practice, in which formal fidelity, historical responsibility and commitment to the qualified circulation of the work in the target culture are articulated.

In this horizon, the responsible visibility of the translator and the critical use of foreignization are articulated with an expanded conception of cultural responsibility. Translating a literary work, especially when it is a first insertion in the arrival system, implies intervening in the ways of reading, interpreting and valuing that work. The translator thus participates in the processes of canonization, circulation, and symbolic legitimation, contributing to the construction of the author's image and the literary tradition to which he or she belongs.

In this way, translation choices cannot be understood only as technical or stylistic solutions, but as culturally situated acts, crossed by power relations, institutional expectations and regimes of sensitivity. Assuming cultural responsibility means, in this context, recognizing that each decision — whether related to lexicon, syntax, rhythm or historical references — interferes in the way alterity will be perceived, negotiated or eventually neutralized in the target culture.

From this perspective, the ethics of alterity formulated by Berman (2007) and the critique of invisibility proposed by Venuti (2008) converge to a conception of translation as a practice of committed cultural mediation. The translator does not act as a simple transmitter or as an autonomous author, but as an interpretative agent who responds simultaneously to the source text, to the reader's horizon and to the historical conditions of reception. The cultural responsibility of translation lies, therefore, in the ability to articulate formal fidelity, historical awareness and critical commitment to the qualified circulation of the work.

3 NORMS, SYSTEMS AND INSTITUTIONAL CONDITIONINGS: REFLECTIONS ON EQUIVALENCE, EFFECT AND PRAGMATICS

If Berman (2007) and Venuti (2008) emphasize the ethical and cultural dimension of translation, Toury's (1995, p. 54-58) contributions allow us to shift reflection within the concrete literary systems in which translation takes place. According to the author, translation is not an isolated act of individual will, but a standardized activity, guided by historically and culturally determined conventions. In this sense, translation choices are crossed by institutional expectations that define what is considered acceptable or appropriate in a given reception context.

By distinguishing between preliminary, initial and operational norms, Toury (1995) shows that the translation process is regulated at multiple levels: from the selection of works to be translated to microtextual decisions regarding syntax, lexicon and style. These norms and devices, although not always made explicit, are internalized throughout the translator's training and professional practice, configuring a horizon of possibilities within which the choices become intelligible.

In the context of the present study, this perspective is fundamental, as it allows us to reflect and understand the pressures exerted by the literary system of the cultural community that receives the work to be translated, particularly with regard to the valorization of fluidity, legibility and stylistic transparency. The expectation of a text that "sounds natural" in the target language tends to favor solutions that attenuate marks of estrangement and reduce the formal complexity of the original. In this scenario, the translation project adopted for the memorial novel *Solo queda ssalto 1* (2018) does not ignore such conditionings, but seeks to negotiate them critically, assuming, when necessary, a counter-normative stance, in line with the ethical principles formulated by Berman (2007) and with the criticism of invisibility defended by Venuti (2008).

It is at this point that Nida's (1964) formulations become pertinent, albeit under careful use. In proposing the distinction between formal equivalence and dynamic equivalence, Nida (1964, p. 159) argues that translation should seek to produce in the reader of the target language a response that is "essentially similar" to that experienced by the reader of the original text. This notion, by emphasizing the pragmatic effect and reception, contributes to problematizing the relationship between form, meaning and emotional/affective impact.

However, it should be noted that the indiscriminate application of dynamic equivalence can lead to stylistic simplification and a reduction in the symbolic density of the text. This is because the exclusive emphasis on the immediate effect tends to privilege fluid reception to the detriment of formal complexity, approaching the same domesticating tendencies criticized by Berman (2007) and Venuti (2008). For this reason, in this work, the notion of equivalence is mobilized in an instrumental way and subordinated to the aesthetic and ethical project of the translation of a memorialistic text. Therefore, we seek a situated translation practice, crossed by institutional norms, but which, concomitantly, intends to make choices attentive to the effects produced on the reader, without giving up the preservation of the formal and cultural alterity of the source text.

It is understood, in this sense, that the translation activity is not neutral and that it implies a constellation of factors among which stylistic coherence, the stability of choices and interpretative responsibility orbit. It is, therefore, a relational practice, situated between the source text, the arrival system and the interpretative horizon of the translator.

From this conceptual framework, a theoretical framework is outlined that integrates the ethics of alterity and attention to form as a central axis, while systemic norms and pragmatic effects operate as complementary dimensions. This framework sustains the translation project analyzed, guided by the preservation of the memorialistic voice, historical density and stylistic containment of *Solo queda sar* (2018). Far from functioning as a normative prescription, it is still important to highlight that the theory is mobilized as an instrument for problematizing the choices made, allowing us to understand the translation process as a space for permanent negotiation between ethical principles, institutional conditionings and aesthetic requirements.

4 METHODOLOGY AND ANALYSIS OF THE TRANSLATION PROJECT CONSTRUCTION PROCESS

This study adopts a qualitative and reflective approach, guided by the understanding of literary translation as an interpretive, historical, and ethically situated practice. In line with proposals that defend practice-based research, the investigation articulates the translation

exercise itself with the systematic analysis of the decisions made throughout the process, conceiving translation simultaneously as an object and as a research instrument.

In this direction, the methodological path developed in this work is based on the articulation between hermeneutic reading, stylistic analysis and reflective registration of translation choices. This procedure allows us to understand the translation process not as a mechanical application of theoretical models, but also as a space for permanent negotiation between ethical principles, institutional conditionings and aesthetic requirements.

4.1 CHARACTERIZATION OF THE CORPUS

The corpus analyzed corresponds to the novel *Solo queda salto* (2018), by María Rosa Lojo, an Argentine writer, essayist and researcher whose literary work is recurrently dedicated to the problematization of memory, identity and migratory heritage in the historical context of the twentieth century. of the political ruptures and experiences of displacement that cross the Argentine cultural formation. In this horizon, *Solo queda salto* is inserted as a memorial narrative that revisits, from an intimate and intergenerational perspective, processes of exile, silencing and transmission of memory.

Structurally, the novel is organized into two distinct parts, configured in the form of two diaries. The first part, entitled *Celia's Diary* (1948), consists of twenty-three chapters in which the narrator records events, reflections and reminiscences from her present writing. The second part, corresponding to *Isolina 's Diary* (2018), brings together ten chapters and presents a significant change in narrative voice, establishing another temporal regime, another interpretative horizon and a perspective mediated by historical distance.

This bipartition is not a mere formal resource, but organizes the novel from two distinct enunciative positions, which structure the narrative progression and guide the construction of meanings throughout the work. The coexistence of these two diaries establishes an intergenerational dialogue in which different historical and affective experiences are articulated, without producing discursive homogenization.

The narrators of each part are self-diegetic, but occupy different enunciative positions within the narrative. This alternation of voices contributes to the complexity of the novel and to the pluralization of the modes of elaboration of memory, configuring a narrative field crossed by temporal and affective displacements.

From the formal point of view, one can observe a prose marked by lexical economy, syntactic precision and affective restraint. In graphic-structural terms, the alternation between regular and italic font functions as a structural device for the organization of memory,

differentiating diaristic registration, reflection and sensory reminiscence. Discrete metaphors, semantic fields linked to displacement, home, land, heritage and Galician landscape contribute to the construction of a dense memorial atmosphere, in which silence and ellipse play a central role.

By simultaneously combining individual memory, collective historicity, and rigorous formal elaboration, *Solo queda salto* requires a translation project capable of recognizing and preserving the singularity of its enunciative regimes. The coexistence of two narrators, two historical times and multiple layers of memory imposes specific challenges to translation, especially with regard to maintaining the internal coherence of the voices, preserving temporal fragmentation and mediating cultural references. In this sense, the novel offers a privileged field to investigate translation as a situated interpretive practice, crossed by decisions that articulate form, ethics and cultural responsibility.

4.2 STAGES OF THE TRANSLATION PROCESS

Based on the interpretative reading and the theoretical framework mobilized, an explicit translation project was elaborated, understood as an articulated set of guiding principles for the choices made. This project is based on the valorization of formal and cultural alterity, the refusal of excessive domestication and the search for a moderate foreignization, according to the propositions of Berman (2007) and Venuti (2008). On the macrotextual level, the project sought to theoretically consolidate the criteria related to the preservation of narrative rhythm, temporal fragmentation and memorialistic voice. On the microtextual level, the theoretical constellation guided decisions regarding the lexicon, syntax, the translation of metaphors, the reproduction of oral marks and the treatment of cultural references. At both levels, it was sought to maintain internal coherence and stylistic stability.

Throughout the work, the systematic recording of translation decisions was carried out through reflective notes, successive versions of the text and analytical comments. This material constituted a secondary corpus, used for the analysis of the process. The record allowed the identification of recurrences, impasses, hesitations and reformulations, evidencing the non-linear character of the translation practice. From this material, representative excerpts were selected, in which dilemmas related to voice preservation, opacity management, cultural mediation and negotiation with systemic norms are manifested. The excerpts brought/listed for analysis in this article were analyzed in the light of the theoretical framework adopted, establishing relationships between concrete decisions and conceptual categories, without reducing the process to normative schemes. The analysis was guided by qualitative criteria,

among which the following stand out: (a) stylistic coherence; (b) preservation of formal density; (c) maintenance of relevant cultural brands; (d) adequacy to the translation project; and (e) interpretative consistency. The validation of the choices was not based on abstract notions of correctness, but on the evaluation of their pertinence within the arrival system and their fidelity to the interpretative horizon constructed in the initial stage. This procedure allowed us to recognize both the limits and the potentialities of the solutions adopted.

4.3 HERMENEUTIC READING AND AESTHETIC AND INTERPRETATIVE ANALYSIS

The interpretative stage constituted the foundation of the translation process, guiding the construction of the horizon of meaning from which the subsequent decisions were elaborated. This phase consisted of the complete reading of the work, with special attention to its structural organization, enunciative variations, and the different memory regimes that configure its narrative architecture.

As already described, the novel is organized into two distinct parts and this bipartition implies not only a chronological displacement, but a change of perspective, narrative voice and discursive regime. Each diary establishes its own temporal, affective and interpretative horizon, requiring the translator to pay differentiated attention to the modulations of the enunciation.

In the first part, Celia's account articulates multiple temporal layers. Initially, the present of the diaristic narrative in 1948 is observed, from which the narrator organizes her experience. To this plane are added, in a recurrent way, fragments of the family past remembered, often marked by the use of italics, in which memory erupts as a sensorial and affective experience. In addition, the narrative incorporates moments of conscious reflection on past events, in which the narrator interprets, reorganizes and reelaborates the past in the light of her present.

This distinction proved to be central to the hermeneutic reading, since not every return to the past takes the form of involuntary reminiscence. In passages such as "Desde la venta de la casa volvieron las viejas pesadillas..." (Lojo, 2018, p. 72) , the narrator reconstructs her trajectory through an organized retrospective narrative, marked by causal connections and temporal metaphors — "una zanja cavada entre dos tiempos" — that make explicit the reflective work of memory. It is, therefore, a discursive elaboration of the past, distinct from the fragmentary sensorial irruptions present in other moments of the work.

On the other hand, in the passages marked in italics, one can observe the abrupt emergence of traumatic memory, often associated with bodily perception and spatial disorientation, as in: "todavía lejanos, se oyen los gritos de los hombres que cazan..." (Lojo, 2018, p. 18). In these passages, language privileges sensory accumulation, syntactic

fragmentation and the juxtaposition of images, configuring an enunciative regime distinct from that of retrospective reflections.

The interpretative reading thus favored the analysis of these different modalities of relationship with the past — sensory reminiscence, reflexive elaboration and the present of writing — as structuring operators of the narrative. The alternation between regular and italic fonts, far from being an ornamental resource, functions as a formal device for the organization of memory and the construction of meaning.

In the second part of the novel, corresponding to *Isolina's Diary* (2018), a significant displacement of the narrative voice is observed. The enunciation is marked by greater temporal distance, by an investigative posture and by a logic close to the documentary record, in which the narrator articulates information, documents, family accounts and historical data. In passages such as those in which "informaciones que llegan..." are mentioned, one can perceive the centrality of the circulation of information and the rational reconstruction of the past, in contrast to the fragmented sensory experience that characterizes Celia's writing. This discursive regime brings *Isolina's* writing closer to an interpretative practice aimed at mediating between inherited memory, research and historical elaboration. The text thus takes on a more analytical tone, with a greater presence of explanatory structures, enumerations and external references, requiring the translator to pay specific attention to changes in rhythm, register and information density.

The aesthetic analysis also included the examination of the recurrent use of toponyms and geographical references. The explicit mention of spaces, cities and regions does not operate only as a referential data, but as an identity and cultural marker, inscribing the narrative in concrete historical territories and reinforcing the transnational dimension of the narrated experience. These elements function as indices of alterity, calling on the reader to recognize other cultural communities and other regimes of belonging.

From the translation point of view, the preservation of these toponyms and proper names in Spanish proved to be fundamental to avoid processes of spatial and cultural neutralization, in line with the ethics of alterity formulated by Berman (2007) and with the defense of foreignization proposed by Venuti (2008). The interpretative reading thus allowed us to identify such references as sensitive points of the text, which demand specific mediation strategies.

Inspired by Berman's (2007) reflections on attention to the letter, this stage sought to apprehend the materiality of writing — rhythm, syntax, image chaining and distribution of pauses — as inseparable dimensions of meaning. At the same time, in line with Venuti (2008), the

homogenization of the different narrative regimes was avoided, preserving the internal asymmetries of the work.

In this way, the interpretative stage was configured as a privileged space for the construction of the translation project, in which reading, analysis and reflection interpenetrated. By establishing a hermeneutic horizon attentive to enunciative variations, to the modalities of memory, to the circulation of information and to the territorial inscription of the narrative, this phase grounded the later choices in an in-depth understanding of the aesthetic, historical and ethical singularity of *Solo queda salto*.

4.4 RECORDING THE PROCESS AND ANALYZING THE DECISIONS: THE TITLE AS A SYNTHESIS OF THE TRANSLATION PROJECT

The translation confrontation began with the problematization of the very title of the work, *Solo queda salto*, understood as a condensing nucleus of the aesthetic and ethical tensions that run through the novel. Far from constituting a peripheral element, the title synthesizes the affective regime of the narrative, anticipating its atmosphere of limit, displacement and survival. Its translation, therefore, could not be treated as a merely lexical operation, but as an inaugural gesture of cultural mediation.

The Spanish construction "ground fall" mobilizes a semantic field that articulates remainder, permanence and irreversibility. The verb *quedar* refers to that which subsists after the loss, to that which remains when other possibilities have already been exhausted. It is a formulation that looks retrospectively at an experience crossed by ruptures, placing the enunciator in front of a horizon already marked by absence. The gesture of "jumping", in this context, emerges as an extreme consequence of a previously established condition – not as a voluntary choice, but as a last resort in the face of the impossibility of return.

In view of this scenario, several translation possibilities were considered. The form "*Só resta salto*" was presented as the final solution, as it preserves the impersonal structure of the original and maintains relative syntactic proximity. However, the hypothesis of pluralization was also evaluated – "We can only jump" – an alternative that would emphasize the transgenerational dimension of the narrative and the collective experience of family memory. Although semantically defensible, this solution explicitly introduces a collective subject that does not exist in the source text, stabilizing a reading that the original keeps in suspension and reducing the enunciative ambiguity that constitutes part of its expressive force.

Another possibility examined was the replacement of *quedar* by the verb "*faltar*", resulting in formulations such as "*Só falta salto*" or "*Só falta falar*". At first glance, such solutions present

fluidity and naturalness in Brazilian Portuguese. However, the semantic analysis revealed a significant displacement of the temporal and affective regime. While falling mobilizes a retrospective logic — associated with the residue of experience, permanence after loss and irreversibility — "lacking" projects the statement into the future, suggesting pending, almost completion or final stage to be fulfilled. In the first case, the enunciator is situated in front of a world already crossed by rupture; in the second, the expectation of something yet to be accomplished is established. This reconfiguration alters the symbolic axis of the title, bringing it closer to a pragmatic logic incompatible with the restraint and suspension that characterize the poetics of the novel.

The choice of the verb that translates jump was also discussed. Although "jump" is more frequent in Brazilian Portuguese, its everyday and less metaphorical connotation could reduce the ambiguity of the gesture, bringing it closer to a concrete and literal action. The maintenance of "jump", although less common in colloquial use, preserves greater symbolic density and maintains a slight lexical friction that echoes the strangeness of the original.

The final decision, therefore, was guided by the preservation of the impersonal structure and the maintenance of the verb "to jump", resulting in the formulation "Only one remains to jump". This choice sought to balance intelligibility and formal fidelity, preserving the syntactic indeterminacy and interpretative openness of the title in Spanish. By avoiding both the explanatory pluralization and the prospective reorientation introduced by "lacking", we sought to maintain the tension between individual experience and collective memory that runs through the narrative.

This decision, however, did not come without impasse. The title highlights the central ethical dilemma of the translation project: between the domestication that favors fluidity in the arrival system and the preservation of the author's poetics, marked by ambiguity, restraint and symbolic density. Translating the title implied negotiating between editorial expectations, legibility and cultural responsibility, recognizing that each possible solution reorganized the temporal and affective regime of the work.

The process thus showed that the translation of the title to "Só resta salto" is not configured as a simple linguistic transposition, but as a relational activity, situated between languages, literary systems and different cultural horizons. The choice of the title thus became an example of the translation gesture itself: a conscious mediation between formal fidelity, listening to otherness and insertion in the new system of reception. By assuming this tension as constitutive, the translation project reaffirms literary translation as an ethical and

interpretative practice, in which each decision participates in the construction of the meaning and circulation of the work.

4.5 METHODOLOGICAL LIMITS: CULTURAL MEDIATION, PARATEXT AND INTERPRETATIVE SCOPE

It is recognized that the mediating character of the translation process implies specific limits to the generalization of the results presented here. The analyses developed reflect a situated experience, conditioned by the translator's training, intellectual path and interpretative horizon, as well as by the theoretical choices that guided the translation project. In this sense, the study does not intend to establish universalizable procedures, but to critically reflect on concrete decisions taken within a specific process.

In addition, the corpus layout and the qualitative emphasis adopted favor analytical depth to the detriment of quantitative coverage. The work focuses on representative excerpts from the novel, in which the ethical, formal and cultural dilemmas of translation are more evidently manifested. Such a choice necessarily implies the exclusion of other possibilities of analysis, without, however, compromising the methodological rigor of the investigation.

One of the most evident limitations of the translation process concerns the translation of cultural references strongly rooted in the historical and geographical context of the work, whose full intelligibility cannot be guaranteed only by intratextual solutions. In Chapter 1, for example, the mention of gorse flowers — a thorny plant with intense yellow flowers, extremely resistant and characteristic of the Galician landscape — highlights the difficulty of transposing into Brazilian Portuguese an element that simultaneously carries botanical, symbolic and identity value. The simple lexical translation of the term does not ensure the recognition of its cultural load, nor of its recurrent presence in the imagination of the region of Galicia. In this case, translation mediation proved to be limited, requiring the use of footnotes as a paratextual strategy to preserve cultural alterity without resorting to the substitution or neutralization of the referent.

A similar situation occurs in later passages of the work, such as the reference to "mica pieces" (Lojo, 2018, p. 97), an expression that refers to shiny mineral fragments, associated with the landscape and the narrator's sensory memory. Although the term "mica" exists in Portuguese, its recognition and connotations are not necessarily shared by the Brazilian reader. The maintenance of the term, accompanied by paratextual clarification, constituted, also in this case, a mediating solution that recognizes the limits of intratextual translation in the face of specific cultural and material references.

These examples show that certain dimensions of the text — especially those linked to the materiality of the space, the local flora, and geological or cultural elements unfamiliar to the reader of the target culture — pose challenges that cannot be fully resolved in the body of the translated text. The punctual use of footnotes, far from representing a translation failure, is configured as an ethical mediation strategy, allowing the preservation of the author's poetics and guaranteeing the reader access to layers of meaning that would otherwise be lost or distorted. Reflection on such limits thus contributes to understanding the translation process not as the application of rules, but as a situated, ethical and interpretative practice, whose reach is built precisely on the recognition of its own borders.

5 FINAL CONSIDERATIONS

The present study aimed to analyze the process of translation into Portuguese of the novel *Solo queda salto*, by María Rosa Lojo, from a perspective that articulates ethics, form, system and cultural mediation. By understanding literary translation as an interpretive, historical and situated practice, we sought to show that translation decisions are not configured as isolated technical operations, but as responsible gestures, crossed by aesthetic, institutional and political choices.

From the dialogue with the contributions of Berman (2007), Venuti (2008), Toury (1995) and Nida (1964), it was possible to build an integrated theoretical framework, in which attention to the letter, the criticism of invisibility, the analysis of systemic conditioning and the reflection on pragmatic effects operate in a complementary way. This framework allowed us to sustain a translation project guided by the preservation of otherness, by the refusal of excessive domestication and by the valorization of the formal singularity of the work.

The analysis of the structure of the novel, organized in two diaries and two distinct narrative voices, evidenced the complexity of the regimes of memory and enunciation that cross the narrative. The distinction between sensory reminiscence, reflective elaboration and historiographical mediation proved to be central to guide the construction of the translation, especially with regard to the preservation of the rhythm, temporal fragmentation and affective restraint that characterize Lojo's writing.

The examination of concrete decisions — such as the translation of the title, the treatment of italics, the preservation of toponyms and the use of explanatory notes — demonstrated that the translation process develops through permanent negotiations between formal fidelity, expectations of the arrival system and cultural responsibility. The problematization of these

choices made it possible to make the processual character of translation visible, evidencing its impasses, hesitations and reformulations.

In this sense, the study reaffirms the centrality of the translator as an interpretative agent and cultural mediator, whose role is not limited to the transfer of meanings, but actively participates in the construction of the horizon of reception of the work. The visibility assumed in this work is not configured as a self-referential statement, but as a critical responsibility before the source text, the reader and the historical conditions of circulation.

By explaining the methodological limits and the mediation strategies adopted, the article is inserted in the field of practice-based research, valuing the knowledge produced from the translation experience. Far from proposing universalizable normative models, the study offers a situated reflection, which recognizes the uniqueness of each process and the historicity of the decisions involved.

Finally, it is hoped that this work will contribute to the deepening of the debate on translation authorship, applied methodology and translation as rewriting in the Brazilian context. By dealing with a first translation of a work not yet published in the national literary system, the study reaffirms the role of translation in the expansion of the cultural repertoire and in the circulation of marginalized or little-known literary voices.

As a future development, it is intended to expand the analysis to other novels by María Rosa Lojo, as well as to deepen the investigation on the relationship between memory, writing and translation in narratives of migratory heritage. In addition, the systematic recording of the translation process can support new reflections on the training of translators and on the articulation between research, teaching and professional practice.

In this way, the translation of *Solo queda salto* is understood, in this work, not only as a textual result, but as a reflective, ethical and relational path, in which the listening to otherness, the negotiation with literary systems and the commitment to the qualified circulation of the work are simultaneously inscribed.

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EFFECT OF HYDROCOOLING ON POSTHARVEST QUALITY AND SHELF LIFE OF ARUGULA

EFEITO DO HIDRORRESFRIAMENTO NA QUALIDADE PÓS-COLHEITA E NA VIDA ÚTIL DA RÚCULA

EFFECTO DEL HIDROENFRIAMIENTO SOBRE LA CALIDAD POSCOSECHA Y LA VIDA ÚTIL DE LA RÚCULA



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ABSTRACT

Arugula is appreciated as a food. Hydrocooling promotes the reduction of respiration, transpiration and promotion, promoting quality and extending shelf life. The objective of this work was to analyze the influence of hydrocooling and refrigerated storage on post-harvest arugula conservation. As variable variables were: visual and shelf fresh, loss of leaf mass analysis and byl content. The experiment was fully developed in hydrores design, wet control, experimented in fully developed design (control, wet control, experimented in design) with seven procedures. Data were selected using the normality and homology of variances test, analysis of variance (ANOVA) and mean test (Tukey 5%) in software R version 3.6.3. Visual and shelf analysis on the 8th day of storage showed that arugula was not suitable for commercialization in treatments. The weight loss of fresh leaves was 39% without control, 41% without wet control and 40% without hydrocooling. The chlorophyll content differed only on day 0 of storage. The shelf life hidrolagors do not extend the shelf life 12 °C after arugula or arugula.

Keywords: Agronomy. Foods. Shelf Life.

RESUMO

A rúcula é apreciada como alimento. O hidrorresfriamento promove a redução da respiração e da transpiração, contribuindo para a manutenção da qualidade e a extensão da vida útil pós-colheita. O objetivo deste trabalho foi analisar a influência do hidrorresfriamento e do

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armazenamento refrigerado na conservação pós-colheita da rúcula. As variáveis avaliadas foram: aparência visual e vida útil de prateleira, análise da perda de massa fresca das folhas e teor de clorofila. O experimento foi conduzido em delineamento inteiramente casualizado, com sete tratamentos. Os dados foram submetidos aos testes de normalidade e homogeneidade das variâncias, análise de variância (ANOVA) e teste de médias de Tukey a 5%, utilizando o software R versão 3.6.3. A análise visual e de vida útil no 8º dia de armazenamento demonstrou que a rúcula não era mais adequada para comercialização em nenhum dos tratamentos. A perda de massa fresca das folhas foi de 39% no controle, 41% no tratamento sem controle úmido e 40% no tratamento sem hidrorresfriamento. O teor de clorofila diferiu apenas no dia 0 de armazenamento. O hidrorresfriamento não prolongou a vida útil da rúcula armazenada a 12 °C.

Palavras-chave: Agronomia. Alimentos. Vida Útil.

RESUMEN

La rúcula es apreciada como alimento. El hidrogenfriamiento promueve la reducción de la respiración y la transpiración, contribuyendo al mantenimiento de la calidad y a la extensión de la vida útil poscosecha. El objetivo de este trabajo fue analizar la influencia del hidrogenfriamiento y del almacenamiento refrigerado en la conservación poscosecha de la rúcula. Las variables evaluadas fueron: apariencia visual y vida útil comercial, análisis de la pérdida de masa fresca de las hojas y contenido de clorofila. El experimento fue realizado en un diseño completamente al azar, con siete tratamientos. Los datos fueron sometidos a pruebas de normalidad y homogeneidad de varianzas, análisis de varianza (ANOVA) y prueba de medias de Tukey al 5%, utilizando el software R versión 3.6.3. El análisis visual y de vida útil en el octavo día de almacenamiento mostró que la rúcula ya no era apta para la comercialización en ninguno de los tratamientos. La pérdida de masa fresca de las hojas fue del 39% en el control, 41% en el tratamiento sin control húmedo y 40% en el tratamiento sin hidrogenfriamiento. El contenido de clorofila difirió únicamente en el día 0 de almacenamiento. El hidrogenfriamiento no prolongó la vida útil de la rúcula almacenada a 12 °C.

Palabras clave: Agronomía. Alimentos. Vida Útil.

1 INTRODUCTION

1.1 PROBLEMATIC

Arugula (*Eruca sativa* M.) is a leafy vegetable with a short post-harvest shelf life, small size, and tender leaves with a pungent flavor. It originated from the Mediterranean region and belongs to the Brassicaceae family (BARREIROS et al., 2021). Arugula is highly appreciated as a food, particularly in raw salads, due to its mineral content, such as calcium, sulfur, iron, and potassium (YANG et al., 2021). It is also a source of omega-3 fatty acids and possesses medicinal properties in combating diseases like cancer (TRAKA et al., 2016; WILSON et al., 2017). However, one of the main limitations in arugula production and post-harvest is high temperature, which causes changes in its morphology, metabolism, and preservation (BARREIROS et al., 2021).

Leafy vegetables like arugula are sensitive to high temperatures and prone to dehydration due to their smaller surface area (ÁLVARES et al., 2007). Temperature is the most important factor in the preservation of harvested fruits and vegetables (REES; FARREL; ORCHAD, 2012), once that regulating biochemical and physiological processes, affecting consequently preservation of the nutritional and sensory characteristics of fruits and vegetables (CENCI, 2006). Lower temperatures reduce respiration, preserving aroma, color, flavor, texture, and other quality attributes. Refrigerated storage is recommended as it delays water loss, undesirable metabolic reactions, and decomposition caused by fungi and bacteria (CHITARRA & CHITARRA, 2005).

Various techniques are used in the preservation of fruits and vegetables, such as modified atmosphere packaging with films and waxes, controlled atmosphere storage, refrigerated storage, growth regulators, and irradiation (CARVALHO, 1994). Refrigerated storage aims to reduce the biological activity of the product, inhibit the growth of unwanted microorganisms, lower the ambient temperature, reduce transpiration through the temperature difference with the product, and increase the relative humidity of the environment (CHITARRA & CHITARRA, 2005). Pre-cooling techniques prior to refrigerated storage are employed to rapidly reduce respiration, transpiration, senescence, and ethylene production in harvested produce, thus promoting higher quality for commercial purposes. These techniques delay physiological and biochemical processes that are directly influenced by temperature (FRANÇA et al., 2015; TRAVASSOS et al., 2017; MOREIRA et al., 2019; GUERRA et al., 2020a). Hydrocooling is a pre-cooling technique that utilizes chilled water to lower the temperature of harvested vegetables before transportation, storage, packaging, and marketing. Hydrocooling is a simple, efficient, fast, inexpensive, and beneficial method as it reduces losses

and moisture during the cooling process (GUERRA et al., 2020a). Hydrocooling has proven to be effective in extending the post-harvest shelf life of fruits and vegetables, such as lychee, peach, asparagus, sweet corn, cherry, lettuce, and parsley (ALIQUE et al., 2006; ÁLVARES et al., 2007; AGUILA et al., 2009). Given the context, hydrocooling is a viable and cost-effective alternative as it reduces the "field heat" and leaf dehydration by absorbing water throughout the storage process (TRAVASSOS et al., 2017; MOREIRA et al., 2019).

Pre-cooling techniques prior to refrigerated storage are employed to rapidly reduce respiration, transpiration, senescence, and ethylene production in harvested produce, thus promoting higher quality for commercial purposes. These techniques delay physiological and biochemical processes that are directly influenced by temperature (FRANÇA et al., 2015; TRAVASSOS et al., 2017; MOREIRA et al., 2019; GUERRA et al., 2020a). Hydrocooling is a pre-cooling technique that utilizes chilled water to lower the temperature of harvested vegetables before transportation, storage, packaging, and marketing. Hydrocooling is a simple, efficient, fast, inexpensive, and beneficial method as it reduces losses and moisture during the cooling process (GUERRA et al., 2020a). Hydrocooling has proven to be effective in extending the post-harvest shelf life of fruits and vegetables, such as lychee, peach, asparagus, sweet corn, cherry, lettuce, and parsley (ALIQUE et al., 2006; ÁLVARES et al., 2007; AGUILA et al., 2009). Given the context, hydrocooling is a viable and cost-effective alternative as it reduces the "field heat" and leaf dehydration by absorbing water throughout the storage process (TRAVASSOS et al., 2017; MOREIRA et al., 2019).

Harvested vegetables retain field heat, which needs to be rapidly removed before transportation and storage to maintain their quality. Failure to do so can lead to quantitative losses (mass loss), qualitative changes (flavor, aroma, texture, and appearance), and nutritional losses (GUERRA et al., 2020a). Furthermore, improper management of temperature and air humidity in storage facilities can reduce their shelf exposure time in supermarkets, grocery stores, or farmers' markets, resulting in higher prices and impacting consumers' expenses (TRAVASSOS et al., 2017). Fruits and vegetables are perishable due to their high water content in plant tissues, resulting in a short postharvest shelf life (COELHO et al., 2015). In an attempt to maximize the postharvest shelf life of fruits and vegetables and reduce postharvest losses, it is necessary to understand appropriate practices and technologies for managing each phase, including harvesting, postharvest handling, storage, transportation, distribution, marketing, and consumption (FREITAS-SILVA & VENANCIO, 2010). Knowledge derived from postharvest physiology provides technical insights that can be obtained and applied to extend the storage time without altering their physical, chemical, nutritional, and organoleptic characteristics

(ABREU et al., 1998; ANTUNES et al., 2003). The objective of this study was analyze the influence of hydrocooling and refrigerated storage on the post-harvest preservation of arugula. The hypothesis of the study consisted that hidrocolling reduces.

2 THEORETICAL FRAMEWORK

2.1 HYDROCOOLING

The high perishability and susceptibility of fruits and vegetables to water loss, intensified by high temperatures and improper temperature and humidity management in storage facilities, necessitate the use of post-harvest techniques aimed at reducing metabolic activity and extending the shelf life of the products, both at the shelf and in refrigeration (SOUZA et al., 2017).

Hydrocooling is performed through the application of water spray onto the product or by immersing it in chilled water (water mixed with ice), immediately after fruits and vegetables are harvested and prior to the processes of packaging, storage, and distribution (BETIN et al., 2018). This technique represents a simple, efficient, and cost-effective alternative for vegetable preservation, as its objective is to remove field heat, thereby reducing the metabolic processes that lead to senescence (TEXEIRA et al., 2016).

Post-harvest control methods are employed to minimize or delay deterioration processes in products through storage, transportation, and other techniques, with hydrocooling being one of the most advantageous methods for fresh vegetables (TEXEIRA et al., 2016).

The application of this pre-refrigeration cooling technique is viable in reducing the temperature of harvested fruits and vegetables, which would otherwise occur slowly in a cold storage room. Hydrocooling enables rapid control of temperature and transpiration in harvested fruits and vegetables. Moreover, it can reduce microbial activity, respiratory rates, senescence, and ethylene production (KALBASI-ASHTARI, 2004).

Studies conducted with hydrocooling have shown that this method yields satisfactory results in leafy vegetables by delaying visual wilting, increasing shelf life, and reducing water loss in lettuce (FRANÇA et al., 2015), scallion (TRAVASSOS et al., 2017), and basil (TEXEIRA et al., 2016).

In addition to these vegetables, hydrocooling has proven to be efficient in the post-harvest conservation and extension of shelf life in lychee, peach, asparagus, sweet corn, cherry, lettuce, and parsley (ALIQUE et al., 2006; ÁLVARES et al., 2007; AGUILA et al., 2009; OLIVEIRA et al., 2015).

In lychee fruits, hydrocooling promotes the maintenance of fruit glossiness and delays fruit darkening (AGUILA et al., 2009). In parsley, hydrocooling is effective in reducing temperature, fresh matter loss, and water loss (ALVAREZ et al., 2007).

Fruits and vegetables that are insensitive to excessive moisture or unaffected by it, such as melon, kiwi, leek, spinach, and scallion, can use hydrocooling with refrigerated water as a post-harvest treatment due to its simplicity, practicality, efficiency, and low cost (BETIN et al., 2018).

2.2 POST-HARVEST CONSERVATION

Fruits and vegetables are perishable due to their high water content in plant tissues, resulting in a short postharvest shelf life (COELHO et al., 2015). In an attempt to maximize the postharvest shelf life of fruits and vegetables and reduce postharvest losses, it is necessary to understand appropriate practices and technologies for managing each phase, including harvesting, postharvest handling, storage, transportation, distribution, marketing, and consumption (FREITAS-SILVA & VENANCIO, 2010).

Knowledge derived from postharvest physiology provides technical insights that can be obtained and applied to extend the storage time without altering their physical, chemical, nutritional, and organoleptic characteristics (ABREU et al., 1998; ANTUNES et al., 2003).

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Refrigerated storage aims to reduce the biological activity of the product, inhibit the growth of unwanted microorganisms, lower the ambient temperature, reduce transpiration through the temperature difference with the product, and increase the relative humidity of the environment (CHITARRA & CHITARRA, 2005).

2.3 REFRIGERATED STORAGE

Maintaining relative humidity below the ideal range for fruits and vegetables leads to water loss and alters their quality. On the other hand, relative humidity above the maximum saturation limits (98 to 100%) promotes the development of postharvest rot-causing fungi and bacteria (CHITARRA & CHITARRA, 2005).

Finger & Vieira (2007) recommend that regulating relative humidity should be coupled with a reduction in storage temperature.

Fruits and vegetables have a minimum temperature threshold, and temperatures below the tolerated range can cause injuries. This physiological alteration is known as chilling, which leads to poor ripening, sensory changes, and darkening of the pulp and epidermis. Several factors should be considered before choosing the storage temperature, such as ripeness stage, cultivar, and exposure time (ROSA et al., 2018).

The success of storage depends on certain precautions, such as storing high-quality and healthy fruits and vegetables, as refrigerated storage alone does not prevent the action of pathogens. Temperature should be regulated immediately after harvest, and the ideal temperature for each fruit or vegetable should be determined. Furthermore, the cold chain should not be interrupted until consumption (LUENGO et al., 2007).

2.4 ARUGULA (*ERUCA SATIVA* M.)

The Brassicaceae family is the botanical family with the largest number of vegetable species, and among these, arugula (*Eruca sativa* M.) stands out, being highly appreciated as a food (Figure 1) (FILGUEIRA, 2008). Additionally, arugula is a vegetable of interest due to its hardiness, early maturity, and popular acceptance (VENZON & PAULA JÚNIOR, 2007).

Figure 1

Arugula (E. sativa M.)



Source: Authors, 2022.

Arugula is native to Southern Europe and Western Asia, and in Brazil, it was introduced by the Italians. It possesses a pungent taste and pleasant aroma, along with rapid development and a short life cycle (FERRO et al., 2013; PÉLA et al., 2017). Arugula is predominantly consumed in the form of salads (VENZON & PAULA JÚNIOR, 2007).

In Brazil, the most cultivated species is *Eruca sativa* Miller, represented by the cultivated and broadleaf cultivars. Additionally, there are other smaller-scale crops of the species *Diplotaxis tenuifolia* (L.), known as wild arugula. Harvesting of arugula is done 30 to 40 days after sowing. The leaves should have a length of 15 to 20 cm, be well-developed, green, and

fresh (MINAMI & TESSARIOLI NETO, 1998). In commercial cultivation, arugula is harvested all at once by uprooting the entire plants with leaves and roots. However, it can also be harvested multiple times through leaf cutting, always above the apical bud, promoting regrowth (MINAMI & TESSARIOLI NETO, 1998).

The Southern and Southeastern regions are the major producers of arugula in the country. Arugula can be sown year-round, but satisfactory development occurs only in mild temperatures (FILGUEIRA, 2008). High temperatures stimulate the reproductive phase, resulting in premature flowering and the development of tough and pungent leaves. Despite being a temperate climate vegetable, arugula meets the requirements for cultivation in regions such as the Northeast, as its cycle and cultivation methods resemble those of lettuce and coriander (FILGUEIRA, 2008). Physicians and nutritionists recommend the consumption of arugula due to its essential role as a vegetable in human nutrition. This is attributed to its content of vitamins A and C, minerals such as calcium, sulfur, iron, and potassium, as well as being a source of omega-3 fatty acids and dietary fibers (BARREIROS et al., 2021), all of which are vital for the proper maintenance of the human body (LAURETT et al., 2017).

Furthermore, arugula has a low caloric value, with only 12 calories per cup, making it suitable for inclusion in most diets. It can stimulate the appetite due to its bitter and strong flavor, often added to heavier dishes. However, arugula can also be consumed sautéed, in salads, or as a pizza topping. The combination of arugula and watercress juice promotes detoxification of the body (TRANI et al., 1992). The commercialization of arugula is done in bunches, which are determined by the product packaging, containing 100 to 150 g for plants in conventional cultivation systems and 250 to 300 g in hydroponic systems. The weight and quality of the product depend on the seasonality of production, meaning that during hotter periods, the product has lower quality and availability, while during colder periods, it has higher quality and availability (LIMA, 2018).

The consumer market for arugula in Brazil is small but has the potential for expansion with regular supply and low prices. Arugula prices can reach over R\$ 4.00 in supermarkets in the northern region of the country. In Alagoas, arugula can cost R\$ 1.00 in open markets and R\$ 2.00 in supermarkets (PURQUERIO et al., 2007).

Leafy vegetables undergo senescence due to rapid water loss and catalytic enzymatic action (WILLS et al., 1981). During harvest, the water supply from irrigation and the soil to the plant is interrupted, resulting in transpiration and a reduction in water content in the leaves due to exchange with the environment (SANTOS et al., 2001).

The loss of water accelerates deterioration, primarily through increased catabolic reactions such as chlorophyll degradation (FINGER & VIEIRA, 1997). Senescence in lettuce, as well as in arugula, can be indicated by the degradation of chlorophyll (SANTOS et al., 2001).

3 METHODOLOGY

3.1 RAW MATERIAL, EXPERIMENTAL LOCATION, AND DETERMINATION OF THE HYDROCOOLING TIME PERIOD FOR ARUGULA

The arugula plants were sourced from a local producer and harvested in the early morning hours. They were immediately transported to the laboratory and classified into bunches weighing 80-112g. The temperature of the bunches was then measured using an infrared thermometer (TRAVASSOS et al., 2017).

The bunches were immersed in a bucket containing a 3:3 (v/v) ratio of water and ice at 4°C. Every 5 minutes, two bunches were removed, and their temperature was measured. The hydrocooling time was determined when the temperature stabilized (TRAVASSOS et al., 2017).

The temperature stabilized after 25 minutes, with the bunches reaching 8°C.

The treatments applied were: I - dry control; II - wet control (submerged in distilled water at room temperature); III - hydrocooled arugula (TRAVASSOS et al., 2017). Finally, the plants were stored at 12°C (Figure 2).

Figure 2

Treatments applied in the experiment



Source: Authors, 2022.

3.2 VISUAL ANALYSIS AND SHELF-LIFE EVALUATION

The arugula bunches were evaluated from the moment of harvest and treatment application until the end of the shelf-life period using subjective scores ranging from 0 to 3 (TRAVASSOS et al., 2017), as follows:

- 0 = no symptoms of wilting, yellowing, oxidation, or any other visual sign indicative of quality loss;
- 1 = intermediate symptoms of wilting, yellowing, oxidation, or other visual signs indicative of quality loss;
- 2 = advanced symptoms of wilting, yellowing, oxidation, or other visual signs indicative of quality loss; and
- 3 = unsuitable for commercialization, indicating the end of shelf-life.

3.3 FRESH LEAF MASS LOSS

Throughout the storage period, the arugula bunches will be weighed daily until the end of the shelf-life, as determined by visual analysis. This will be estimated using the equation:

$$PMF = \frac{[(FML-FFM)]}{IFM} \quad (1)$$

Where: FML: leaf mass loss (%);

IFM: initial fresh mass (g);

FFM: final fresh mass (g).

3.4 CHLOROPHYLL CONTENT

The chlorophyll content was measured using a SPAD (Soil Plant Analysis Development) meter.

3.5 STATISTICAL ANALYSIS

The experiment was conducted in a completely randomized design (CRD) with 3 treatments (dry control, wet control, hydrocooled arugula stored at 12°C) and seven replicates. The data were subjected to tests for normality and homogeneity of variances, analysis of variance (ANOVA), and mean comparison using the Tukey test at a significance level of 5% in the statistical software R version 3.6.3 (R CORE TEAM, 2021). Graphs and tables were created using the SIGMAPLOT software.

4 RESULTS AND DISCUSSION

4.1 VISUAL AND SHELF-LIFE ANALYSIS

The visual and shelf-life analysis of rucola stored at 12°C showed the following observations:

On the 4th day of storage, rucola exhibited an intermediate level of wilting, yellowing, oxidation, or other visual signs of quality loss (rating 1).

By the 6th day of storage, rucola showed advanced symptoms of wilting, yellowing, oxidation, or other visual signs of quality loss (rating 2).

Finally, by the 8th day of storage, rucola displayed symptoms that rendered it unsuitable for commercialization, indicating the end of its post-harvest shelf life (rating 3) (Table 1).

The rucola samples already exhibited wilting symptoms in the control, moist control, and hydrocooling treatments after the first day of storage. Between the 4th and 6th day of storage, the rucola samples showed characteristics unsuitable for commercialization but still within the standards observed in some markets and farmer's markets. At the end of the storage period (8th day), the rucola samples demonstrated a deterioration in quality, particularly in terms of weight loss (Figure 3).

Table 1

Visual and Shelf-life Analysis of Rucola Stored at 12°C

Days	Subjective ratings		
	Control	Moist control	Hydrocooled
0	0	0	0
2	1	1	1
4	1	1	1
6	2	2	2
8	3	3	3

Figure 3

Visual and Shelf Life Analysis of Arugula Stored at 12°C



Source: Authors, 2022.

The visual and shelf life analysis is a measurement used to monitor the visual and nutritional deterioration of fruits and vegetables during storage (TRAVASSOS et al., 2017). It also serves as a means to identify the optimal storage period after a treatment is applied to any plant or animal-derived product, such as oranges or tomatoes subjected to refrigerated storage. In our study, the period was set at 8 days after cooling.

The visual and shelf life analysis can be performed using developed scoring scales, such as the one proposed by Travassos et al. (2017), or it can be provided by specific institutions, such as the United States Department of Agriculture (USDA) for the classification of potato sticks (CRUZ et al., 2021).

4.2 PERCENTAGE LOSS OF FRESH LEAF MASS (%)

The percentage loss of fresh leaf mass of arugula stored at 12°C did not differ statistically among the treatments (Table 2).

Table 2

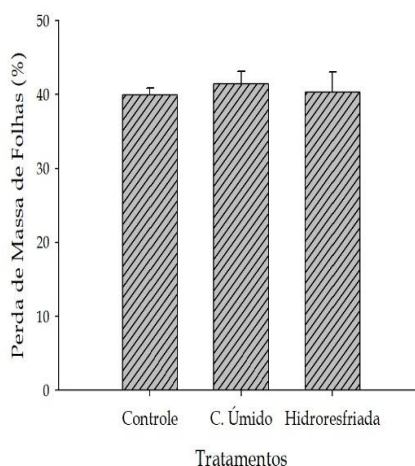
Analysis of Variance (ANOVA) of the percentage loss of dry leaf mass

	GL	SQ	QM	Fc	Ft
Trat.	2	7,4	3,7	0,01	0,98
Res.	19	3451,8	191,77		
Total	21	3459,2			
C.V.	34%				

The percentage loss of fresh leaf mass of arugula stored at 12°C was 39% for the control, 41% for the moist control, and 40% for the hydrocooled arugula on the 8th day of storage (Figure 4).

Figure 4

Percentage loss of leaf mass (%) of arugula stored at 12°C



The main cause of fresh mass loss in leafy vegetables is the transpiration process during storage. This not only leads to mass loss but also decreases the overall quality of the product (SILVEIRA et al., 2015).

Water loss promotes various changes in the appearance (Figure 2), metabolism, and composition of leafy vegetables (KAYS & PAULL, 2004), resulting in alterations in color, nutrients, and vitality (WILLS et al., 2007). Some water loss is allowed during refrigerated

storage as long as it does not compromise the quality of the product displayed in commercial locations, due to wilting and wrinkling (GUERRA et al., 2020b).

On the 8th day of storage, the arugula in terms of fresh leaf mass loss was already unsuitable for commercialization, as percentages >40%, in the case of both the moist control and hydrocooled samples, are not acceptable. This result is due to leafy vegetables like arugula being composed mainly of water, constituting a content of 85 to 95% (NUNES et al., 2013).

In addition to the composition of arugula, another crucial factor is the relative humidity (RH) during refrigerated storage. The composition of 85 to 95% water, small specific area, and 100% intracellular spaces promote transpiration and water exchange to the environment with lower humidity (CRUZ et al., 2021).

Furthermore, the fresh mass loss in stored fruits and vegetables can be attributed to the evaporation of retained water after washing, as respiration, which involves the oxidation of carbohydrates into carbon dioxide and water, occurs due to the dehydration process caused by the difference in water vapor pressure between the vegetable's interior and the surrounding environment (MOREIRA et al., 2006).

As a result, wilting caused by water loss during storage is considered a significant quality attribute, as it is not accepted from a consumer's perspective (NUNES et al., 2013).

4.3 TEOR DE CLOROFILA

The chlorophyll content differed among the treatments on day 0 of storage, but there was no significant difference on the subsequent storage days (Table 3).

Table 3

Chlorophyll content of stored arugula 12°C

Dias	Chlorophyll		
	Control	Moist control	Hydrocooled
0	34,9a	35,3b	32,9b
2	35,5	35,1	33,8
4	33,7	35,0	33,5
6	32,6	32,6	33,2
8	29,7	31,7	33,0

Different letters in the rows indicate that the treatments differ significantly from each other at a 5% level of significance based on the Tukey's test.

The chlorophyll content indicates the amount of nitrogen present in the leaves and helps in identifying possible deficiencies resulting from excess water and leaching of nitrogen from

the soil (WINDER, 2018). Despite no significant differences from the 2nd to the 8th day of storage, the chlorophyll content decreases over the storage period. Therefore, it can be inferred that hydrocooling in arugula promoted chlorophyll degradation. A similar result was found by Álvares et al. (2007) in hydrocooled cilantro leaves.

The chlorophyll content can also indicate degradation due to metabolic processes occurring during storage (LANFER-MARQUEZ, 2003). Furthermore, chlorophyll degradation in senescent tissues may involve thermal alterations, which can occur in fruits or vegetables subjected to hydrocooling (HEATON et al., 1996).

Enzymatic reactions contribute to the brownish coloration in vegetables during the senescence period, attributed to the formation of phaeophytins and pheophorbides or the action of polyphenol oxidase (PPO) and peroxidase (POD) enzymes (LANFER-MARQUEZ, 2003).

5 FINAL CONSIDERATIONS

The results of this study indicate that hydrocooling did not extend the post-harvest shelf life of arugula stored at 12 °C, based on the results of visual and shelf life analysis, fresh leaf mass loss, and chlorophyll content. The effectiveness of hydrocooling as a technique for arugula preservation needs further investigation.

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GENETIC BASES OF HETEROSIS AND ITS CONTRIBUTION TO MODERN AGRICULTURE

BASES GENÉTICAS DA HETEROSE E SUA CONTRIBUIÇÃO PARA A AGRICULTURA MODERNA

BASES GENÉTICAS DE LA HETEROSIS Y SU CONTRIBUCIÓN A LA AGRICULTURA MODERNA



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ABSTRACT

Heterosis, or hybrid vigor, is the phenomenon in which hybrid individuals exhibit superior performance compared to their parents, particularly in traits such as growth, productivity, and physiological vigor. This phenomenon is of great importance in plant breeding and is widely used in crops such as maize and rice, where it significantly contributes to increased agricultural productivity. Studies on heterosis began in the 18th century with hybridization experiments and were later expanded by researchers such as Mendel, Darwin, and Shull, who observed greater vigor in plants derived from crosses compared to those obtained through self-fertilization. From these studies, heterosis began to be applied in the production of hybrid cultivars. Several hypotheses have been proposed to explain the genetic basis of heterosis, with the dominance, overdominance, and epistasis theories standing out, involving different forms of gene interaction. Despite scientific advances, the phenomenon is still not fully understood and remains the subject of studies in molecular genetics and genomics. The measurement of heterosis can be performed using different methods, comparing the performance of the hybrid with that of its parents or with standard cultivars. Its application provides benefits such as higher productivity, plant uniformity, and greater efficiency in genetic improvement. Thus, heterosis represents one of the most important contributions of genetics to agriculture, being essential for the development of more productive cultivars adapted to market demands.

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Keywords: Genetic Improvement. Gene Interactions. Hybrid Vigor.

RESUMO

A heterose, ou vigor híbrido, é o fenômeno em que indivíduos híbridos apresentam desempenho superior em relação aos seus genitores, destacando-se em características como crescimento, produtividade e vigor fisiológico. Esse fenômeno possui grande importância no melhoramento genético de plantas, sendo amplamente utilizado em culturas como o milho e o arroz, onde contribui significativamente para o aumento da produtividade agrícola. Os estudos sobre heterose tiveram início no século XVIII, com experimentos de hibridação, sendo posteriormente aprofundados por pesquisadores como Mendel, Darwin e Shull, que observaram maior vigor em plantas provenientes de cruzamentos em comparação àquelas obtidas por autofecundação. A partir desses estudos, a heterose passou a ser aplicada na produção de cultivares híbridas. Diversas hipóteses foram propostas para explicar a base genética da heterose, destacando-se as teorias da dominância, sobredominância e epistasia, que envolvem diferentes formas de interação entre genes. Apesar dos avanços, o fenômeno ainda não é totalmente compreendido, sendo objeto de estudos em genética molecular e genômica. A mensuração da heterose pode ser realizada por diferentes métodos, comparando o desempenho do híbrido com seus genitores ou com cultivares padrão. Sua utilização proporciona benefícios como maior produtividade, uniformidade das plantas e maior eficiência no melhoramento genético. Dessa forma, a heterose representa uma das mais importantes contribuições da genética para a agricultura, sendo fundamental para o desenvolvimento de cultivares mais produtivas e adaptadas às necessidades do mercado.

Palavras-chave: Melhoramento Genético. Interações Gênicas. Vigor Híbrido.

RESUMEN

La heterosis, o vigor híbrido, es el fenómeno en el que los individuos híbridos presentan un desempeño superior en relación con sus progenitores, destacándose en características como crecimiento, productividad y vigor fisiológico. Este fenómeno posee gran importancia en el mejoramiento genético de plantas, siendo ampliamente utilizado en cultivos como el maíz y el arroz, donde contribuye significativamente al aumento de la productividad agrícola. Los estudios sobre heterosis comenzaron en el siglo XVIII con experimentos de hibridación y posteriormente fueron profundizados por investigadores como Mendel, Darwin y Shull, quienes observaron un mayor vigor en plantas provenientes de cruzamientos en comparación con aquellas obtenidas por autofecundación. A partir de estos estudios, la heterosis pasó a aplicarse en la producción de cultivares híbridos. Diversas hipótesis fueron propuestas para explicar la base genética de la heterosis, destacándose las teorías de la dominancia, sobredominancia y epistasia, que involucran diferentes formas de interacción entre genes. A pesar de los avances científicos, el fenómeno aún no se comprende completamente y sigue siendo objeto de estudios en genética molecular y genómica. La medición de la heterosis puede realizarse mediante diferentes métodos, comparando el desempeño del híbrido con sus progenitores o con cultivares estándar. Su utilización proporciona beneficios como mayor productividad, uniformidad de las plantas y mayor eficiencia en el mejoramiento genético. De esta manera, la heterosis representa una de las contribuciones más importantes de la genética a la agricultura, siendo fundamental para el desarrollo de cultivares más productivos y adaptados a las necesidades del mercado.

Palabras clave: Mejoramiento Genético. Interacciones Gênicas. Vigor Híbrido.

1 INTRODUCTION

One of the greatest events in the history of plant breeding was the discovery of the phenomenon of heterosis, also known as hybrid vigor. Heterosis represents the superiority of the hybrid over its parents. According to FEHR, 1987, heterosis is the increase in vigor, plant height, carbohydrate content, productivity and intensity of physiological phenomena among contrasting individuals.

The heterosis value can be quantified using the difference between the mean values of generation F1 and of parents father 1 (P1) and father 2 (P2), with the result expressed as a percentage, considering the average value of the parents equals 100. However, for practical and commercial purposes, heterosis is measured in relation to the superior parent (heterobeltiosis) or of greater economic importance (standard heterosis) (PATERNIANI, 1974).

Growth rate, fertility, biomass and productivity are among the traits where heterosis, or hybrid vigor, is often evaluated in plants. In no other cultivated species, heterosis had, and continues to have, as much impact as in maize, responsible for a continuous increase in productivity in the last century. But heterosis is also observed in autogamous species, such as rice. The impact of the use of hybrid vigor in rice is responsible for the large increase in crop productivity in China, and now in other countries. This result, again, is due to the combination of classical breeding methods based on extensive phenotypic analysis (FERREIRA ; FALEIRO, UNDATED).

For the breeder of vegetable or fruit species, the visual aspect and the size of the fruit are often more important than the productivity itself. For example, the Hawaii papaya market values fruits with an average weight of 200 to 250 grams. In this case, heterosis will become undesirable if its manifestation results in fruits with weight above these values (BORÉM; MIRANDA, 2009).

Several hypotheses have been elaborated in an attempt to explain the phenomenon of heterosis, highlighting the theses of dominance, overdominance and epistasis. All these hypotheses suggest that the contribution of many genes is responsible for the greater vigor of hybrids in relation to inbred lines.

2 HISTORY OF HETEROSIS

Heterosis began to be studied by Koelreuter (1761-1766), who observed in an experiment with tobacco crossing that the F1 hybrids had more vigor and that such hybrids received the characteristics of their parents. After Koelreuter's experiments, Mendel and Darwin

in experiments carried out with crossbreeding, they also realized that plants were larger than plants from self-fertilization (MOTA, 2011).

Gregor Mendel, in 1865, crossed peas with a length of 0.30m x 1.80m and obtained in the F1 generation plants between 1.80m and 2.25m, observing the superiority of the descendants.

Charles Darwin (1876) made detailed observations of various characteristics (height, weight, number of grains, color, fertility, etc.) in a wide and varied set of plants, comparing plants that were self-fertilized with plants of the same species crossed. Among the observations carried out, sterility and lower vigor in the self-fertilized offspring of some species stand out. Although this study has great repercussion due to the volume of information collected regarding the effects of inbreeding and heterosis, it does not delve into the mechanisms of inheritance.

The hybridization work began with BEAL using intervarietal hybrids (BEAL, 1876), EAST (1908) and SHULL (1908, 1909) who established the inbreeding-hybridization system and JONES (1918), who suggested the use of double hybrids to enable the commercialization of the hybrid seed, these being the major initial contributions to the success of hybrid maize.

According to Goldman (1999), Darwin's work (1876) was inspired by botanist Asa Gray, mentor of William James Beal, who pioneered the modern concept of heterosis. Beal has focused his career on the production of intervarietal hybrids and the control of corn pollination.

The work developed by Beal and his students was repeated, conducted by George Espy Morrow and Frank Duane Gardner in 1890. The results indicated that individuals from controlled crosses showed wide variation in ear dimensions and higher productivity than the average of the parents (Morrow and Gardner, 1893), data that corroborate the results previously obtained by Beal.

In 1909, the American botanist and geneticist Shull showed that by fertilizing the plant with its own pollen, less vigorous offspring were produced. By repeating the process over the next seven or ten generations, the descendants fixed important agronomic characteristics. Plants that generated genetically similar offspring came to be called pure lines. SHULL noticed that two different pure lines, when crossed with each other, produced offspring with great vigor, called hybrid vigor or heterosis, giving rise to hybrid maize (CIB, 2006).

Heterosis only became important in plant genetic improvement after the studies of George Shull (1908), as he was the first to suggest how heterosis could be used to develop new cultivars, interpreting that heterosis is the opposite of depression by inbreeding. Shull believed that hybrid vigor was correlated with the degree of dissimilarity between gametes.

According to him, the greatest difference in the union of the gametes, up to a certain limit, increases the stimulus or vigor. (JOSÉ, 1992; CARBONERA, 1990).

The main expected effect of heterosis is related to a substantial increase in productivity and, without a doubt, the greatest impact produced by its use was on the production of hybrid corn, which, from the 20s onwards, began to be widely used in the United States and, later, in numerous other countries, and is therefore natural. that broader data are more available for maize than for another crop (PATERNIANI, 1975).

3 GENETIC AND MOLECULAR BASIS OF HETEROSIS

Since its beginnings, modern genetics and plant breeding programs have tried to explain why, in certain crosses, the F1 hybrid is superior to the performance of homozygous parental lines, or the most vigorous of parental lines. There is great expectation about the unveiling of the molecular and physiological principles that are behind the phenomenon of heterosis. Molecular biology and genomics have recently contributed to shed light on the issue and potentially offer new strategies to capitalize on the hybrid increase in force by genetic improvement programs (FERREIRA ; FALEIRO, UNDATED).

Quantitative characters are influenced by allelic interactions. It can be of the additive type, complete or partial dominance, or overdominance. It is observed that in the additive interaction, the mean of F1 is equal to the mean of the parents, does not explore heterosis and symmetrical distribution is found in the F2 generation. In the dominance and/or overdominance interaction, the average of F1 is different from the average of the parents, and can explore heterosis. In this case, there is an asymmetric distribution in the F2 generation.

Several hypotheses have been suggested to explain the genetic basis of heterosis, including the dominance, overdominance, and epistasis hypotheses.

3.1 THE DOMINANCE HYPOTHESIS

The hypotheses to explain heterosis propose that hybrid vigor is the result of non-additive effects on the phenotype. The Dominance Theory was proposed by Bruce (1910). According to this theory, heterosis is a function of the accumulation of favorable dominant loci of different loci.

Model: $AA = Aa > aa$

$AA=10$ $Aa=10$ e $aa=0$

Parental 1
 $aaBBccDDee = 20$

x

Parental 2
 $AAbbCCddEE = 30$

F1

$AaBbCcDdEe = 50$

$AABBCCDDEE = 50$

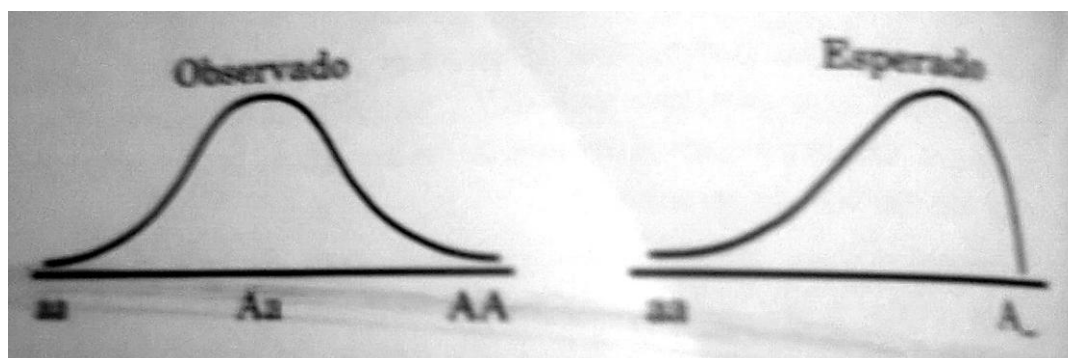
(1)

The main objection to this theory is that, theoretically, it would be possible to find inbred lines (homozygous) as productive as hybrids, which has never been observed in practice. Proponents of this theory respond to this objection by stating that the probability of this occurring is very small, due to the large number of genes involved.

According to Borém and Miranda (2009), in the first years after the proposition of the main hypotheses explaining heterosis, these were much questioned in several specialized journals. The dominance hypothesis was objected to four times in the debate forums. The first is that some researchers considered it too simplistic and non-explanatory. The second refers to the distribution in the F2 generation, which should be asymmetric, of the type $(3A_+ + 1aa)^n$, for n genes that affect the trait in question.

Figure 1

Expected and observed distributions of heterosis in the F2 generation



Source: Google, 2026.

The third objection questioned the need for heterozygosity for the expression of vigor. It was argued that, if this hypothesis were correct, it would be possible to obtain an individual equally vigorous as an F1 hybrid and homozygous with respect to favorable dominant genes. However, an individual as vigorous as F1 has never been found that did not segregate.

In 1917, Jones introduced the concept of factorial linkage in the debates on heterosis and stated that hybrid vigor was a function of the interaction of dominant or partially dominant favorable alleles, coming from both parents. He also argued that if large numbers of alleles were involved in the manifestation of vigor, they would be linked and it would be extremely difficult to obtain all favorable alleles in a single homozygous individual.

The fourth objection to this hypothesis is based on the lack of evidence of dominance in the expression of quantitative traits. This criticism was immediately removed from the discussions, due to the experimental results that indicate partial or complete dominance as the main mode of inheritance of quantitative traits.

3.2 HYPOTHESIS OF OVERDOMINANCE

Theory that believes that the vigor presented by the F1 plants is due to high heterozygosity, that the union of the two allelic forms of the heterozygote is superior to the separate action of any of the alleles in homozygosis; the variability of protein forms in heterozygous plants would make them more efficient in the face of varying environmental conditions (CROW, 1948).

$$\begin{array}{lcl} & AA\ BB\ CC\ dd & + \quad aa\ bb\ cc\ DD \\ \text{Value} & 10+12+10+5 = 37 & 5 + 7 + 8 + 10 = 30 \end{array}$$

$$\begin{array}{lcl} F1 & Aa\ Bb\ Cc\ Dd & \\ \text{Value} & 11+13+11+11 = 46 & \end{array}$$

(2)

There are many cases in which the gene action of dominance has been detected, and very few cases of the occurrence of overdominance.

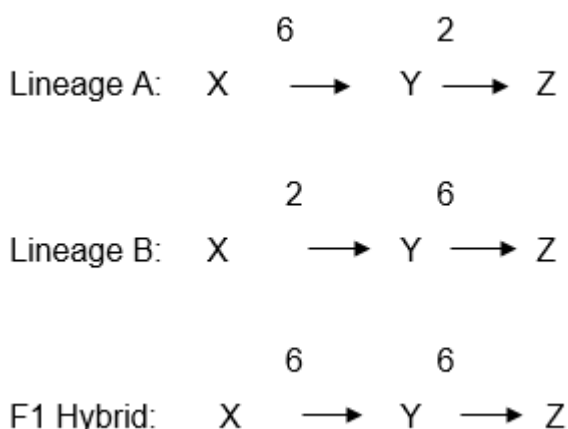
3.3 HYPOTHESIS OF EPISTASIS

The epistasis hypothesis considers the interallelic epistatic interactions of two or more loci as the main factor of superiority in the phenotypic expression of a trait in hybrids and involves the epistatic effects additive x additive, additive x dominant and dominant x dominant (POWERS, 1945; BETRÁN et al., 2004).

Epistasis was also investigated by PATERNIANI (1974) as to its possible effect on heterosis. For corn, it proved to be important in terms of days for flowering, ear height and productivity.

According to Borém and Miranda, 2009, epistasis can explain heterosis in the following situations:

- **Complementary gene action.** Considering that the A_bb and $aaB_$ parents have a relative value equal to zero, the hybrid $AaBb$ of the cross of these parents may express heterosis with a relative value equal to 2. The gene segregation of two complementary genes, such as those previously described, is 9:7 in the F_2 generation. This same idea is extended to quantitative characters, that is, there is a need for favorable alleles from all *loci* for the manifestation of heterosis.
- **Limiting reaction.** Considering that vigor occurs due to a series of reactions that can be limiting



(3)

In lines A and B, only two units of product Z are produced, due to the limitation imposed in one of the stages of the reaction, while in the hybrid, because of the epistatic action of the genes, six units of Z are produced. This hypothesis was presented by Hegeman, Leng and Dudley, in 1967, in the article "A biochemical approach to corn breeding".

- **Multiplicative sum.** Considering the total production of maize seeds with the result of the number of rows of seeds and the number of seeds per row on the cob, also considering that the number of rows and the number of seeds/row are complementarily additive characteristics, the hybrid F_1 will present intermediate values to the parents for the number of rows and seeds/row, but it will manifest heterosis as to the total number

of seeds. This explanation of heterosis based on the multiplicative sum between additive traits was presented by Mayo (1980).

4 GENETIC COLLINEARITY AND HETEROSIS

Conclusions about the genetic causes of heterosis are difficult, because the quantitative genes involved in the control of traits are still poorly known (BERNARDO, 2002). Two areas of genomics have recently been used to understand heterosis: the analysis of the structural genome, on the one hand, through the re-sequencing of genomic regions that contain QTLs associated with the control of heterosis; and the analysis of global gene expression, in general, through DNA microarrays. The contribution of the analysis of the structural genome of some maize gene regions reveals that, at least in this species, heterosis and depression by inbreeding can be explained by the numerous deletions/insertions of genes and retrotransposons identified in regions that, theoretically, should be collinear in the genome of the species (FU; DOONER, 2002).

The model of complementation of non-collinear regions is compatible with the dominance hypothesis, and explains both the observed vigor and the depression by inbreeding. The model may also explain why genetic distance, by itself, is not a good indicator of hybrid vigor. In other words, if several lineages of a species are analyzed based on polymorphism of molecular markers and the data used to estimate genetic distance, the hybrids between the genetically most distant lineages are not necessarily the ones with the greatest heterosis. However, this may be true when lineages are derived from common ancestors that have undergone insertions/deletions over time, characterizing different complementary groups that, in essence, would be the basis of heterotic groups. Skeptics of the structural genomics explanation for hybrid vigor suggest that the evaluation is adequate for maize, but other mechanisms must be acting on the expression of heterosis, since differences in microcollinearity would not be as significant in other species as observed in maize (FERREIRA ; FALEIRO, UNDATED).

Figure 2

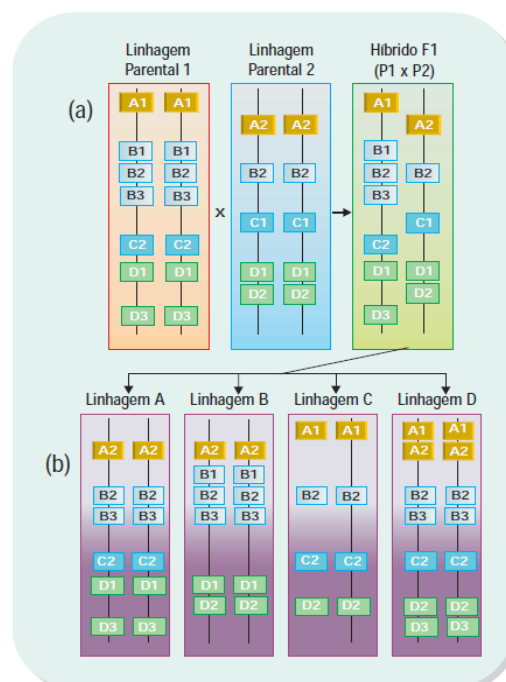


Fig. 5. O re-seqüenciamento de regiões do genoma associadas ao controle de heterose em linhagens de diferentes grupos heteróticos de milho (*Zea mays* L.) indica que a alteração de microcolinearidade nestas regiões do genoma é responsável pela heterose em híbridos F1 e por depressão por endogamia. O vigor híbrido é explicado por complementação de genes de diferentes famílias gênicas (A, B, C e D) nas regiões seqüenciadas (a). A depressão por endogamia é explicada pela ausência de genes na região seqüenciada em linhagens puras derivadas do híbrido F1 depois de repetidas gerações de recombinação e autofecundação (b).

Source: Google, 2026.

5 MEASURING HETEROSIS

Different concepts can be used to measure the degree of heterosis of a cross. Traditional heterosis is calculated by the difference between the value of the hybrid (F1) and the average of its parents (P1 and P2).

Traditional heterosis:

$$h (\%) = F1 - (P1 + P2 / 2) \times 100 \quad (4)$$

Another concept that can be used is that of heterobiosis, which estimates the degree of heterosis in relation to the best parent (PM).

$$3 \text{ Heterobiosis } (\%) = F1 - MP \times 100 \quad (5)$$

In standard heterosis, heterosis is estimated in relation to a standard cultivar (CP).

$$\text{Standard Heterosis (\%)} = F1 - CP \times 100 \quad (6)$$

6 IMPORTANCE OF HETEROSIS FOR AGRICULTURE

Heterosis is one of the greatest contributions of Genetics to world agriculture. According to PATERNIANI (1978) the advantages of using hybrid or heterosis vigor are:

- Associate characteristics of different parents in the shortest possible time;
- Obtain superior genotypes in a relatively short timeframe;
- Use gene interactions in hybrid generation;
- Produce uniform genotypes;
- Achieve less interaction with the environment in the F1 generation;
- To produce hybrid corn seeds commercially, with favorable effects on the region's economy.

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BRAZIL AND THE US IN THE FTAA NEGOTIATIONS – WHO WINS AND WHO LOSES?

BRASIL E EUA NAS NEGOCIAÇÕES DA ALCA – QUEM GANHA E QUEM PERDE

BRASIL Y ESTADOS UNIDOS EN LAS NEGOCIACIONES DEL ALCA: ¿QUIÉN GANA Y QUIÉN PIERDE?



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ABSTRACT

This study analyzes the negotiation process of the Free Trade Area of the Americas (FTAA), highlighting the leading role and divergent strategies between Brazil and the United States. Initiated in 1994, the proposal aimed at the economic integration of the continent, but faced significant obstacles arising from economic asymmetries and the lack of common objectives among the main actors. The article uses a bibliographic and documentary approach to evaluate the tactics adopted: while Brazil sought to strengthen Mercosur as an independent bloc and adopted a defensive posture to delay the agreement, the US aimed to consolidate its regional hegemony. With the definitive end of negotiations in 2005, the US resorted to bilateralism with countries on the Pacific coast and in Central America, while Brazil focused on South American institutionalization. The work concludes by presenting a synthesis of the distribution of costs and benefits of this regional integration for these two countries.

Keywords: FTAA. Brazil. United States.

RESUMO

Este estudo analisa o processo de negociação da Área de Livre-Comércio das Américas (ALCA), destacando o papel protagonista e as estratégias divergentes entre o Brasil e os Estados Unidos. Iniciada em 1994, a proposta visava a integração econômica do continente, mas enfrentou obstáculos significativos decorrentes das assimetrias econômicas e da falta de objetivos comuns entre os principais atores. O artigo utiliza uma abordagem bibliográfica e documental para avaliar as táticas adotadas: enquanto o Brasil buscou fortalecer o Mercosul como bloco independente e adotou uma postura defensiva e protelar o acordo, os EUA visavam consolidar sua hegemonia regional. Com o encerramento definitivo das negociações em 2005, os EUA recorreram ao bilateralismo com países da margem pacífica

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e da América Central, enquanto o Brasil focou na institucionalização sul-americana. O trabalho conclui apresentando uma síntese da distribuição de custos e benefícios dessa integração regional para esses dois países.

Palavras-chave: ALCA. Brasil. Estados Unidos.

RESUMEN

Este estudio analiza el proceso de negociación del Área de Libre Comercio de las Américas (ALCA), destacando el protagonismo y las estrategias divergentes entre Brasil y Estados Unidos. Iniciada en 1994, la propuesta buscaba la integración económica del continente, pero enfrentó importantes obstáculos derivados de las asimetrías económicas y la falta de objetivos comunes entre los principales actores. El artículo utiliza un enfoque bibliográfico y documental para evaluar las tácticas adoptadas: mientras Brasil buscaba fortalecer al Mercosur como bloque independiente y adoptó una postura defensiva para retrasar el acuerdo, Estados Unidos aspiraba a consolidar su hegemonía regional. Tras la finalización definitiva de las negociaciones en 2005, Estados Unidos recurrió al bilateralismo con países de la costa del Pacífico y Centroamérica, mientras que Brasil se centró en la institucionalización en Sudamérica. El trabajo concluye presentando una síntesis de la distribución de costos y beneficios de esta integración regional para ambos países.

Palabras clave: ALCA. Brasil. Estados Unidos.

1 INTRODUCTION

The intention to create the Free Trade Area of the Americas (FTAA) emerged in 1994 at the first Presidential Summit of the Americas. The main objective was to promote economic integration and free trade among all the countries of the American continent. From the launch of such a proposal to the end of its negotiations, some obstacles related to the economic disparities of the countries involved become evident. Thus, the lack of common objectives between Brazil and the United States (USA), the main protagonists of this negotiation table, stands out.

The main objective of Brazilian foreign policy was to delay the negotiation process. The strategy, therefore, was to negotiate from Mercosur acting as an independent sub-regional bloc. This initiative reflected the fact that Brazil intended to assert itself as a large regional and even world economy, and feared integration into the same space to which it included the American economy. Such elements relied on defensive positions based mainly on the diagnosis of the fragility of some Brazilian industrial sectors.

The main interests of the U.S. in the creation of the FTAA were to strengthen its bargaining power vis-à-vis Europe and the countries of East Asia, and to create a single regional integration that would promote Latin America in global spheres, keeping the U.S. as the main agent (*hub*). This process can be seen as a deliberate attempt by the U.S. to consolidate its hegemony in the Western Hemisphere by integrating Latin American economies with those of North America and legitimizing an integration agenda.

The fourth Summit of the Americas in 2005 definitively marked the end of the FTAA negotiations. With the end of the possibility of a comprehensive hemispheric agreement, the U.S. government sought to establish free trade agreements with individual countries, including Chile, Peru, Colombia, and Ecuador, while Brazil sought to establish South America as an enlarged market. The difference between such strategies is that while the US sought more specific and detailed agreements with the different countries, Brazil aimed at greater multilateral institutionalization in an attempt to build a regional identity.

Therefore, this article has the following objectives: First, to carry out a bibliographic and documentary research on the main aspects of the FTAA negotiations. Then, analyze the negotiation strategies adopted by Brazil and the USA. And finally, to evaluate the possible losses and gains of this regional integration for these two countries.

2 FTAA NEGOTIATIONS

The intention to create a Free Trade Area of the Americas called FTAA (FTAA) emerged at the first Presidential Summit of the Americas, held in Miami in December 1994, at the call of the then President of the United States (USA) Bill Clinton. Thirty-four heads of state were summoned⁴ and approved at the end of the meeting a declaration of principles and a plan of action. The first referred to preserving and strengthening democracy in the Americas; promoting prosperity through economic integration and free trade; eradicate poverty and discrimination on the continent; ensure sustainable development and preserve the environment. The action plan, on the other hand, had as a central element the commitment to promote economic integration and free trade in the hemisphere. In this sense, the Special Trade Commission of the OAS (Organization of American States), with the support of the Inter-American Development Bank (IDB) and ECLAC (tripartite committee), was delegated the systematization of data and studies of the integration arrangements with the description of rights and obligations. The main objective was to determine the points of coincidence and divergence, aiming to improve the link between the different disciplines and make them more homogeneous. At first, it was decided that the negotiations should be concluded in 2005 (FTAA, 2004).

In 1995, 1996 and 1997, three meetings of foreign trade ministers were held. It was determined that the FTAA should build on the existing sub-regional and bilateral agreements, make them more similar, with a view to expanding and deepening continental integration. The significant differences in the size of the economies and in the levels of development of the countries involved were recognized, thus seeking ways to facilitate the integration of less developed countries. Therefore, working groups were created in several areas, such as: i) access to markets; (ii) customs procedures and rules of origin; iii) services and investments; iv) standards of technical, sanitary and phytosanitary barriers to trade; v) subsidy, anti-dumping measures and countervailing duties for economies of menres; vi) government purchases; vii) intellectual property rights; viii) competence policies and dispute resolution; among others (DE GINZBURG, 2004).

Between 1998 and 2003 there were two other Summits of Heads of State and five other ministerial meetings. In general, it was reaffirmed that the FTAA agreement would be balanced,

⁴ The heads of state and government of Antigua and Barbudas, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Dominica, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Granidas, Suriname, Trinidad and Tobago, participated in the meeting. Uruguay and Venezuela, all members of the OAS (Organization of American States). Cuba, although a member of the OAS, was suspended from participating in the activities of this organization (FTAA, 2004).

broad, and consistent with WTO guidelines,⁵ and that it would constitute a single commitment. Considering, also, the need to implement a transparent negotiation process, and, even more importantly, taking into account the differences in the level of development and size of the economies, to facilitate the full participation of all participating countries. In this sense, the declaration issued in the final phase of the negotiations recognizes the need for flexibility so that countries could assume different levels of commitments, allowing for an adequate balance of rights and obligations. Such measures included technical assistance and transition mechanisms, such as the application of longer deadlines for the fulfillment of some obligations (FTAA, 2004).

From the launch of the proposal to create the FTAA until the deadline for negotiations, it became evident that this period was not sufficient to solve some obstacles related to disparities in the economies of the participating countries. This asymmetry is highlighted by the participation of the world economic power and Latin American and Caribbean countries. In the specific case of the latter, participation in a continental arrangement implies evaluating and reconciling national and regional interests with hemispheric ones. In reality, it is a question of cost-benefit analysis that is not trivial for such an integration. Not all effects are quantifiable by the volume of imports and exports and by the trade balance, because this relationship involves much more than the trade results (DE GINZBURG, 2004).

At the heart of this frustration is the lack of common goals between Brazil and the United States (USA), the main protagonists of this regional negotiation table. The first was determined to facilitate the market for agricultural goods and trade countervailing measures (*anti-dumping*). The second pursued new trade issues, such as: services, rules for foreign investments, government procurement and intellectual property rights. In addition, Brazil and Argentina proposed a model in which different topics were discussed on separate "tracks". This alternative proposal was designed to face the liberalization of trade in goods on the one hand, and on the other, it would involve these new trade issues, giving the option to these countries to adhere or not to the deeper integration agreements (OLIVEIRA, 2009, p. 193).

⁵ It should be noted that the criterion adopted was aimed at a conciliatory formula to accommodate the existence of a multiplicity of bilateral agreements and various integration schemes. The main ones are: the North American Free Trade Agreement (Canada, Mexico and the USA, 1994); the Group of Three (Colombia, Mexico and Venezuela, 1994); the Central American Common Market (Consisting of the five countries of Central America, 1960); the Caribbean Community (made up of the Caribbean countries plus Belize, Guyana and Suriname, 1973); the Andean Community (Bolivia, Colombia, Ecuador, Peru and Venezuela, 1996); and Mercosur (Argentina, Brazil, Paraguay and Uruguay, 1991).

2.1 BRAZIL STRATEGIES

Confrontations between the U.S. and Brazil in multilateral trade negotiations go back much longer than the Doha Round in 2001 or the election of a leftist government in Brazil in 2002. The main arguments against Brazil's adherence to a process of continental integration had in common a belief in the superiority of protectionism, and an anti-Americanism fostered by US unilateralism, in its policies towards Latin America⁶ (ALBUQUERQUE, 2006). Such arguments can be grouped into five categories: i) *Global trader argument*: Brazil has a characteristic of internationally balanced trade and has an interest in all regions of the world; ii) *Argument of Mercosur's superiority*: in commercial terms, in political and cultural issues, in addition to not embedding inequalities of dimensions such as that of the FTAA; iii) the argument of American disinterest/unilateralism: the U.S. priorities would be in Europe and the Asia-Pacific, and the FTAA would be a reflection of American unilateralism and its constant search to mark its hegemony in the region; iv) *Argument of the superiority of the European Union*: an agreement with the EU would be more advantageous for Brazil for various reasons; and v) *scrapping argument*: the service sector and industry would be scrapped with an increase in competition with the US. In other words, easier access to the domestic market would lead to a displacement of American subsidiaries back to their headquarters, since they could export to Brazil. In addition, the increase in competition would lead to the bankruptcy of the companies with non-US capital installed here.

Based on this context, the main objective of Brazilian foreign policy was to delay the negotiation process⁷. "The Brazilian government responded to the Initiative for the Americas, from a rhetorical point of view, by not saying yes or no" (ALBUQUERQUE, 2006). According to Rompay (2004, *apud* TEXEIRA, 2011), Brazil was clearly the least enthusiastic country in advancing hemispheric integration, among all the other participants, in 1991, on the occasion of the first Summit of the Americas. The strategy, therefore, was to negotiate from Mercosur acting as an independent sub-regional bloc. Such a choice was intended to avoid the notion of US hegemony and to serve as a counterweight to the NAFTA bloc. "It was a clear answer: the first priority for both countries [Brazil and Argentina] was their integration into the subregion, and continental integration would be a step to be considered later." (ALBUQUERQUE, 2006, p. 565). In 1994, Brazil, Argentina, Paraguay and Uruguay signed the Ouro Preto Protocol that

⁶ These opinions were defended by a broad front formed by the high civil and military bureaucracy, the majority of the business community, the union leaderships, the academic and communication media. It should be noted that for the author, the arguments are summarized in generic terms and cannot be attributed to a specific sector of the government or civil society.

⁷ The "rationality" of this strategy was the conviction of some domestic actors with some capacity to influence Brazilian foreign policy, that Brazil would only lose with the FTAA. "Those who only have to lose, have everything to gain by gaining time" (ALBUQUERQUE, 2006).

complemented the 1991 Treaty of Asunción and formalized Mercosur. This gave it legal personality within the scope of international law, endowing it with effective capabilities in international negotiations. The following year, the four countries implemented a common external tariff (CET) covering about 85% of goods traded within the bloc. It is, therefore, an important advance in the process of regional integration, becoming a customs union⁸ (TEIXEIRA, 2011, p. 191).

In 1995 the European Union and Mercosur signed the "Interregional Framework Agreement on Cooperation". The objective was to establish a broad political and economic partnership, based on three fundamental pillars: political dialogue, cooperation, and trade and investment. The latter aimed at creating a free trade area. "The strong historical and cultural ties between the countries on both sides of the Atlantic, which led to the existence of large colonies of European emigrants [...] are largely responsible for the existence of significant trade and investment flows from the EU to Mercosur." (PINTO AND GUIMARÃES, 2005, p. 4). In this sense, in the EU's understanding, such flows must be preserved and even expanded, and the strengthening of Mercosur would provide this objective. Part of this interest of the EU in establishing the agreement must be analyzed in the light of the process of formation of the FTAA, precisely to oppose the interests of the US in Latin America. In addition, by establishing economic relations outside Mercosur, such as with the EU, the countries of the bloc aimed to increase their negotiating capacity with the United States and in the discussions of the process of creating the FTAA itself.

This initiative reflected the fact that Brazil intended to assert itself as a large regional and even world economy, and feared integration into the same space to which it included the American economy. "Brazil is in good interest to strengthen Mercosur, as this allows it to have greater power in the FTAA negotiations. This negotiating power could also be strengthened if Mercosur establishes the association agreement with the EU." (PINTO AND GUIMARÃES, 2005, p. 9). According to Valladão (1998), only a strict cooperation between Europe and Latin America could guarantee the diversity and specificity of these two blocs in the face of the 'North American steamroller'.

In addition, many argued that Mercosur had a continental vocation from the beginning. The aim was to create a broad free trade area in Latin America beyond the limits of the southern cone. In 1996, for example, it signed association agreements with Chile and Bolivia, which was

⁸ Two points should be highlighted: first, Mercosur is an imperfect customs union, considering the fact that some of the goods were outside the scope of the TEC. Secondly, and from an economic point of view, Mercosur has been the second largest bloc in terms of trade flow in the hemisphere, after NAFTA, and the fourth largest in the world (TEIXEIRA, 2011).

renamed "political Mercosur". In this context, Brazil's strategy was to lead the formation of a South American bloc with the objective of institutionalizing South America and increasing the costs for the establishment of the FTAA. This would secure and reinforce its position within the South American subsystem, in order to prevent its absorption into a broader hemispheric system. Then-President Fernando Henrique Cardoso referred to Mercosur as "[...] a pole from which the South American space [would be organized]" (CARDOSO, 1998, p. 127 *apud* TEIXEIRA, 2011, p. 192). The objective was to create obstacles for greater US penetration in South America, and according to Teixeira (2011), it was facilitated by the lack of leadership on the part of the US in relation to the countries of the region.

The FTAA negotiations were in fact launched at the second Summit of the Americas, in April 1998, in Santiago, Chile. Top leaders agreed that the final product should be a single commitment⁹, and that countries could negotiate as members of a sub-regional economic bloc. These were important diplomatic victories for Brazil and Mercosur. "The idea that countries could negotiate as blocs legitimized Mercosur's position in the negotiations, and allowed smaller countries to increase their influence. [In addition], through sub-regional blocs it was possible to reduce the enormous asymmetries of bargaining power, and smaller countries could even reject some agreements." (CARRANZA, 2004, p. 321). Specifically, Brazil sought to balance the FTAA negotiations with the U.S. in two ways: by forging a single South American negotiating bloc capable of standing up to the U.S.; and courting other trading partners to reduce its dependence on the U.S. "Brazil wants to consolidate itself as a regional hegemon in South America, and feels that the presence of the U.S. competes with this objective." (FAURIOL AND PERRY, 1999, p. 32-33). It should be noted that the Brazilian elites were preferable to a sub-regional integration (Mercosur) to a hemispheric integration¹⁰.

In addition, the Mercosur countries did not consider the FTAA as a priority in their trade policy, due to the bloc's own economic structure and trade pattern¹¹. On the one hand, these countries had a diversified economic structure, being both producers of primary goods and manufactured goods. In 1999, three-quarters of Mercosur's exports were manufactured goods, 24% of which were characterized by high economies of scale and intensive in natural resources. The rest, primary goods, agricultural commodities accounted for 15% of total exports. On the other hand, countries such as Brazil and Argentina had, in this period, very diversified trade

⁹ The Single Commitment Requirement preserved flexibility for *trade-offs* and prevented the U.S. from achieving incremental liberalization of sectors considered sensitive through interim agreements (CARRANZA, 2004, p. 321).

¹⁰ In a survey carried out, 66.2% of the sample agreed with the statement: "Brazil must prioritize integration into Mercosur". On the other hand, the statement: "Brazil should prioritize a free trade agreement with the United States" was chosen by only 16.4% of the interviewees (DE LIMA, 1996, p. 155, *apud* CARRANZA, (2004).

¹¹ The then President Fernando Henrique Cardoso declared: "Mercosur for us is a destination, while the FTAA is only an option, which we will join only under favorable conditions" (FOLHA, 1998).

patterns. Thus, 20% of Mercosur's total exports were to the bloc itself, 29% were to the rest of the Americas, 26% to the EU and 25% to the countries of the "rest of the world" (OSIMANI, 2005, p. 52). According to Ruiz (2007, p. 300), this economic structure and trade pattern are crucial to understand the rejection of the FTAA by the Mercosur countries, led by Brazil.

Mercosur has been the space in which Brazil has continued its industrialization process. For example, the automobile sector was regulated by a special regime that limited extra-regional imports. However, many Brazilian and Mercosur industrial sectors are certainly less competitive than those of the USA, and would certainly be displaced in a possible FTAA scenario (RUIZ, 2007, p. 300).

However, the official Brazilian strategy for free trade on the continent has not always been unanimous in South America. Argentina and Chile, two of the largest countries in the region, were very enthusiastic about the possibility of reaching an agreement with the United States, preferably even before the 2005 deadline. The Argentine government became one of the most ardent supporters of this alliance during most of the 1990s. This was characterized as a complete historical reversal of his contentious stance towards the US.¹² In this context, a logical outcome would be a trade agreement with the U.S. and even NAFTA membership was considered. However, Argentina could not freely sign a bilateral agreement with the U.S. due to the existence of the Mercosur TEC. In addition, the country did not want to create problems with Brazil, which was the most important market for its products. In 1994, the year before the Ouro Preto protocol, Argentina exported twice as much to Brazil as to the USA. Thus, Brazil was able to contain Argentine enthusiasm with reasonable success during the FTAA negotiation stages¹³ (TEIXEIRA, 2011).

In terms of the economic situation, Mercosur survived the regional financial crisis triggered by the devaluation of the Mexican currency in December 1994. At the end of that decade, Mercosur's problems were exacerbated by unfavorable external conditions, such as: the Asian crisis of 1998-99; falling commodity prices and slowing world trade. In addition, divergences in macroeconomic policies between Brazil and Argentina have become a serious political problem for the bloc. After the devaluation of the Brazilian currency in January 1999, Mercosur was the scene of several trade disputes. "Mercosur survived, but the integration

¹² An indication of this renewed relationship is the fact that Argentina dispatched warships to the Gulf War in 1991, the only Latin American country to do so. In 1998, the United States, as a form of retribution, designated Argentina as a "great non-NATO ally", also the only country in the region to have this distinction (FAURIOL and PERRY, 1999, p.33, *Apud*, TEIXEIRA 2011).

¹³ On the other hand, the restrictions that applied to Argentina were not valid for Chile. The country was not part of Mercosur and the US was a much more important country for Chilean exports than Brazil. In addition, its development strategy had as a key component a greater openness to international trade (TEIXEIRA, 2011).

process lost strength, despite the attempt to 'relaunch' the bloc in 2000¹⁴" (CARRANZA, 2007, p. 325). That same year, then-President Fernando Henrique Cardoso described the meeting as a "moment of reaffirmation of South America's identity as a region. [adding that] a free trade agreement between Mercosur and the Andean Community¹⁵ will be the backbone of South America and an extended economic space. [Therefore], it must be seen as a political objective of immediate interest" (CARDOSO, 2000, *apud* CARRANZA, 2007, p. 203).

The economic recession between 1998 and 2002 in Argentina generated several negative consequences for Mercosur. First, it was a severe blow to the flow of intra-bloc trade and investment, aggravated by Brazil's recession after the currency devaluation in 1999. Exports among member countries fell from 25% in 1998 to just 11% in 2002. Brazilian exports to Argentina fell by more than 60% in 2002; and Brazilian imports from Argentina fell by about 26% (IADB, 2002, *apud* CARRANZA, 2004, p. 326). Second, the difference between Argentina's fixed exchange rate and the periodic devaluations of the Brazilian currency threatened Mercosur's survival. The coalition against the devaluation in Argentina favored the country closing an agreement with the US, and reverting Mercosur from a common market to a free trade area. This has raised the tenor of trade disputes between the countries, and the insistence on maintaining exchange rate parity in Argentina has made it impossible to harmonize macroeconomic policies¹⁶.

The implosion of the Argentine economy in December 2001 reopened the debate on the viability of Mercosur in the broader context of the FTAA negotiations. Most analysts feared that the Argentine crisis would have a negative impact on Mercosur, and that a populist regime in Argentina could hurt Brazilian companies investing in that country. A weak Argentina means a weaker Mercosur, undermining Brazil's negotiation strategy for the creation of a Free Trade Area of the Americas (CARRANZA, 2004, p. 326).

However, the Argentine crisis of 2001-02 had a positive aspect for Mercosur. The absence of U.S. leadership with the crisis has strengthened political solidarity among Mercosur partners. At the beginning of 2002, at an extraordinary meeting of Mercosur, the presidents of Brazil, Uruguay and Chile promised full support to Argentina and asked the institutions linked to the international financial sector to understand the complex situation in which the country is going through. The objective was to obtain financial aid to implement an economic recovery

¹⁴ In 2000 it was the first exclusive meeting of South American presidents. The Brazilian government has officially signaled its attempt to rally the South American market around the Brazilian political project of organizing a South American space, as a way of inserting the region into the international system in the post-Cold War era.

¹⁵ Includes: Bolivia, Peru, Ecuador, Colombia and Venezuela.

¹⁶ In January 2002, the currency devaluation in Argentina eliminated the main source of conflict between this country and Brazil. In this way, both countries were able to achieve a higher level of macroeconomic convergence.

program, demanded by the then Duhalde government. In fact, at the same meeting, there was talk of strengthening Mercosur as a trade bloc and even advancing in the implementation of a single currency. Thus, the U.S. policy of letting Argentina solve its own problems eroded the prospects for the FTAA, because, according to Carranza (2007), it even contradicted the "Washington Consensus", on which the original proposal of continental integration was based.

Other Latin American countries might draw conclusions that there was no reward for being a "friend" of the U.S. [...] The absence of U.S. support for Argentina at a time of crisis bodes very poorly for the building of a long-term economic community in the hemisphere. If that's what community means, it doesn't mean much. [...] Prescriptions for economic policies based on free markets were discredited, and the US would have to accommodate at least some demands from Latin American countries, during the market access negotiations that began in November 2002 (CARRANZA, 2004, p. 327).

In this context, the results of the ministerial meeting in Miami in 2003, in the final phase of the FTAA negotiations, were considered a victory for Brazilian diplomacy¹⁷. The so-called "FTAA à la carte" or "light FTAA" was a not so comprehensive FTAA with different levels of commitment. The Miami ministerial declaration stated that the "Ministers recognize that countries can make different levels of commitments, and that negotiations should allow countries, if they so wish, to agree or not to obligations and obtain additional benefits." (MINISTERIAL DECLARATION, 2003, *apud*, TEIXEIRA, 2011, p. 205). It should be noted that this "FTAA à la carte" was received with skepticism by the US and Canadian negotiators, and even some analysts in Brazil "complained that the plan would be counterproductive and would not be able to gain traction" (DEBLOCK and TURCOTE, 2005, p. 7).

The main controversies of these negotiations included liberalization of agricultural products, trade reservations (*anti-dumping measures*), intellectual property rights, and environmental and labor standards. The first of these, in the FTAA negotiations, was considered the most sensitive and controversial. A critical point was whether the agreement would eliminate or regulate agricultural subsidies and other disruptive trade practices¹⁸. That is, minimum entry price schemes; escalation and tariff peaks; mandatory labeling and certifications; non-scientific criteria applied to agricultural products; and technical and phytosanitary barriers. One of the main points of discussion was whether such measures would have a magnitude in the FTAA

¹⁷ In 2003, the new government of Brazil under Lula da Silva saw the integration of South America as a foreign policy priority. In 2004, during the third meeting of South American presidents in Peru, Mercosur and the Andean Community formalized a cooperation agreement, thus creating the "Community of South American Nations" which later became the "Union of South American Nations" or UNASUR (TEIXEIRA, 2011).

¹⁸ Part of the complexity of the negotiations was the result of significant protectionism on the part of the countries importing agricultural products. Among these, the following stand out: sugar, orange juice and citrus products, tobacco, cotton, soybeans and meat (RIVAS-CAMPO, 2003).

negotiations or in the WTO. The U.S. position was that such barriers should be discussed at the multilateral level. The argument was that a regional agreement would not cover countries outside the region, such as Japan and members of the European Union, which granted heavy subsidies to the agricultural sector. Given this U.S. position of encouraging global rather than regional liberalization in agriculture, Latin American countries began to wonder about the gains of an FTAA without agricultural liberalization. In fact, this was a major concern given that developing countries are heavily dependent on this sector. In addition, because the U.S. was reluctant to eliminate its agricultural subsidies, Latin American countries "argued that dropping or eliminating tariffs on agricultural products while maintaining the option for subsidies would be insufficient and unfair, because it would deprive developing countries of protecting their own sector, given the high cost of such measures to least developed countries." (RIVAS-CAMPOS, 2003, p. 670).

At the domestic level, Brazil and Argentina evaluated the reduction of tariffs in areas considered sensitive, more common in economies of non-central countries. These analyses were linked to the demands of the two most interested sectors: the agro-exporter and the industrial. The first of these was in favour of access to new markets, although he opposed the subsidy policy of the central countries, which made access to them difficult. The second group, in general terms, opposed greater external competition caused by a general tariff reduction on goods and services. They thus argued that such a measure should be staggered and include the possibility of using protection mechanisms. Nevertheless, some large companies and economic groups supported trade liberalization, due to the possibility of enjoying access to new markets, being convinced of the ability to resist a higher level of competition (KAN, 2018, p. 5).

From the associative and corporate point of view in Brazil, the creation of the Brazilian Business Coalition (CEB) stands out¹⁹, which was configured as a multisectoral organization of business leadership entities. It included various trade union representation organizations, private companies with domestic capital, foreign capital and state-owned companies. The explicit objective was to intervene in the FTAA negotiations. "The idea was to organize itself to ensure a coordinated participation of Brazilian businessmen in the negotiation process, without the hegemony of the Ministry of Foreign Affairs" (SANTANA, 2000, p. 69 *apud* KAN, 2018).

The CEB was open to various proposals from companies, but in the end the opinion of the group prevailed, which opposed the acceleration of hemispheric integration proposed by the US government. However, according to Castelan (2016), such a position was not as obvious

¹⁹ In addition to bringing together several specific sectors, CEB was commanded by the main entities of Agro, such as CNA (Confederation of Agriculture and Livestock of Brazil), and industry, such as CNI (National Confederation of Industry), and to a lesser extent by FIESP (Federation of Industries of the State of São Paulo) (KAN, 2018).

as it may seem. On the one hand, and in macroeconomic terms, in fact the US seemed to be a threat to Brazil. The Latin American and Caribbean region, by and large, was among the few regions in the world with which the U.S. maintained a trade surplus²⁰.

the damage associated with the FTAA in the minds of the Brazilian state bureaucracy [can] be summarized in the following equation: the external vulnerability of the Brazilian economy is a function of the deficit in the balance of payments, which is a function of the deficit in the balance of trade, which is a function of the low competitiveness of our exports, whose most appropriate symbol is the reversal of the bilateral balance with the United States [...]. The political class generally shares the perceptions of the bureaucracy regarding the fatality of the damage caused by competition with the US and, in turn, tends to extend this fear to foreign competition in general (ALBUQUERQUE, 2006, p. 572).

On the other hand, the U.S. has always been a major market for Brazilian industrial products. At the end of the 1990s, 70% of Brazilian exports to the USA were made up of manufactured products, while those destined for the EU were only 38% (PEREIRA, 2001, p. 36 *apud* CASTELAN, 2016). It is common for governments to consider aggregate data and give greater importance to balance of payments results, but not to represent specific sectors. In this sense, the protectionist position of the CEB in favor of gradualism and selective agreements did not seem as obvious as one might suppose²¹.

As for the businessmen [...]. The understanding that protectionism has costs as well as benefits, and that the two must be compared, is a process that is developing sector by sector, branch by branch, as the growing inseparability between import and export costs becomes evident to sectors subjected to competition. Generally speaking, no one refuses additional protection unless the costs—disproportionate increases in inputs or threats of retaliation—become all too evident. Thus, [...] the vast majority of the business community [...] saw in the FTAA more harm than good (ALBUQUERQUE, 2006, p. 572, 573).

In short, the FTAA negotiations were complex and relied on defensive positions based on the diagnosis of the fragility of some Brazilian industrial sectors. According to Oliveira (2009, p. 184), there was an inability of Brazilian policymakers to renounce an administered policy, and to commit themselves to the challenges imposed by the new regionalism and globalization. Thus, the Brazilian negotiators lacked a more objective stance in relation to the costs and benefits of adhering to a project such as the FTAA.

²⁰ The United States had a trade surplus with the region of about US\$ 12.3 billion in 1998 (SANTANA, 2000, p. 40).

²¹ In 2005, the year in which the FTAA negotiations stalled, seven of the ten industrial activities that exported the most had the US as their main destination. The textile-clothing industry, although not dependent much on exports, saw in hemispheric liberalization an opportunity for access to the American market. Finally, the agricultural and food products sector was the one that showed the greatest support in favor of the FTAA (CASTELAN, 2016).

2.2 US STRATEGIES

There are different interpretations of the U.S. initiative to launch the FTAA at the Summit of the Americas in 1994. The first was based on the "Washington Consensus", that is, a set of prescriptions such as greater trade liberalization, deregulation and privatization that could even lead Latin American countries out of the recession of more than a decade. The opening of the markets of neighboring countries would allow the creation of the continental regional bloc and would also help to face the increase in trade protectionism in Europe and Asia (MASI and WISE, 2005, p. 308). Therefore, part of the U.S. interest in the FTAA can be interpreted as going beyond that of economic benefits, given the "possibilities it offers for the reinforcement of the structural and ideological foundations of U.S. hegemony, consistent with its parallel global strategies" (PHILLIPS 2003, p. 331).

According to Pinto and Guimarães (2005), such interests have been particularly relevant for much longer than the beginning of the FTAA negotiations. Latin America is a region that the U.S. has become accustomed to considering as its natural influence and where it has exercised its economic, political, and military supremacy for several decades²². In 1990, a period in which the US focused on the development of NAFTA, the then US President George Bush launched the proposal "Initiative for the Americas", which established Latin America as an area of influence of the US. This proposal aimed to prevent another economic power, such as the European Union, from acquiring a prominent role in the region. In this sense, the U.S. intended NAFTA to become an integration model to be expanded to all of continental America, especially Brazil²³. It should be noted that members of the later Clinton administration expressed several times that Mercosur was seen as harmful to the FTAA and a threat to hemispheric regionalism (CARRANZA, 2000).

A second interpretation points to the U.S. concern with creating the necessary institutions to increase the flow of exports and foreign direct investment (FDI) from the U.S. to Latin America. In that case, the FTAA would be a means for the U.S. to expand in the region in the same way that NAFTA was used to gain a larger market share in Mexico²⁴. Breaking down trade and investment barriers, especially in South American countries, would also prevent U.S.

²² Examples are the interventions in Panama (1914), Haiti (1915), the Dominican Republic (1916), Nicaragua (1925-1933) and the support given to many of the political dictatorships that favored the economic interests of the United States (PINTO and GUIMARÃES, 2005).

²³ In 1994, President Bill Clinton's request for a fast track concession to negotiate the NAFTA agreement had already implied its extension to all of Latin America. "Fast track is a request made to Congress by the U.S. president to be able to negotiate trade agreements without having to wait for the usually lengthy decision of Congress." (PINTO and GUIMARÃES, 2005, p. 5).

²⁴ President Clinton had hoped that the conclusion of NAFTA would allow the U.S. to "use the Mexican precedent to enter the rest of Latin America" (FEINBERG, 1997, 58).

companies from suffering discrimination in the context of a free trade agreement between them and the European Union or East Asian countries²⁵ (MASI and WISE, 2005, p. 308).

The last interpretation is that U.S. objectives in the hemisphere should be considered in light of the difficulties of trade negotiations within the WTO, such as in the Doha round. In this sense, the gradualist and fragmented nature of integration through the FTAA was seen as a more promising option for the US.

One of the main reasons for U.S. interest in an FTAA stems from the opportunity it presents to push a new trade agenda, at a time when progress in multilateral trade negotiations appears precarious, and when the diminishing ability of the U.S. to control the multilateral agenda has been a cause for political concern. The result was that promoting the trade agenda in the Americas seemed increasingly inviting than continuing to fight against numerous obstacles in the multilateral arena (PHILLIPS, 2003, p. 332).

From these different interpretations of the U.S. interest in hemispheric integration, two main elements stand out. First, the FTAA is seen by the US as a way to strengthen its bargaining power vis-à-vis Europe and East Asian countries. Secondly, the FTAA would be a single regional integration that would promote Latin America in global spheres, keeping the US as the main agent (*hub*). This would also allow for the deepening of reforms and market liberalization in Latin America, diluting the complex "patchwork" of sub-regional agreements that has evolved on the continent since the early 1990s.

This process can be seen as a deliberate attempt by the U.S. to consolidate its hegemony in the Western Hemisphere by integrating Latin American economies with those of North America and legitimizing an integration agenda. The latter incorporates: i) the effort to expand international rules on trade, investment and services in a future FTAA; ii) effort to eliminate differences in national regulatory regimes and their discriminatory effects on trade and investment. These included rules on property rights, differences in national standards, financial, industrial, technological, competition, and environmental policy issues; iii) the objective of reducing or even eliminating the differences in corporate policies, and the structures of industrial policies that imposed restrictions on trade and investment (HAGGARD, 1995, *apud* CARRANZA, 2004, p. 320).

Since the beginning of the FTAA negotiations, two different views on the character of the integration process have collided. These two points of view were represented by the two largest

²⁵ Because the U.S. has comparative advantages primarily in trade in services and high-tech goods, a reduction in Latin American trade barriers would pave the way for U.S. companies in the region. This explains the position of the United States, since the beginning of the negotiations, to include new issues such as: liberalization of the service sector, investments, government procurement and issues such as intellectual property rights (MASI and WISE, 2005, p. 309).

economies in the American continent, the USA and Brazil, and their respective regional subsystems. While the US aimed at an expansion of NAFTA to the entire continent, as part of a broader vision of a new world order, Brazil wished to consolidate its position in the South American subsystem, and saw the FTAA as an obstacle to this (TEIXEIRA, 2011, p. 195). In 2003, the two countries adopted apparently intransigent positions and showed a lack of political commitment to make concessions. In addition, the U.S. became more protectionist during the Bush administration and less willing to compromise on issues of interest to Latin America, such as agricultural subsidies and anti-dumping measures applied to Latin American exports, especially to Brazil (CARRANZA, 2007, p. 321).

While maintaining its commitment to reaching a multilateral regional agreement, the U.S. has also resorted to bilateralism with the aim of working on the disarmament of Mercosur as an integration project, trying to isolate Brazil from the rest of its partners. "[The U.S.] would send signals to Central America and Caribbean countries for proposals for free trade agreements; [this] would give the prospect of permanent preferential access to the U.S. market before the Andean countries; [in addition] it would restart negotiations for a free trade agreement with Chile; and would tempt Argentina and Uruguay to negotiate outside the Mercosur framework" (MASI and WISE, 2005, p. 314).

The fourth Summit of the Americas in Mar Del Plata (Argentina), in 2005, definitively marked the end of the FTAA negotiations. Among the thirty-four participants, twenty-nine expressed themselves in favor of moving forward in the negotiations, the five dissident nations were composed precisely of the four members of Mercosur plus Venezuela, which a month later was invited to join the Bloc as a permanent member. This event, according to Teixeira (2011), was a perfect illustration of how Brazil used Mercosur as the core of its strategy of establishing a free trade zone in the region, to counter the American strategy. With the end of the possibility of a comprehensive hemispheric agreement, the Bush administration sought to establish free trade agreements with individual countries, including Chile, Peru, Colombia, and Ecuador, while Brazil sought to establish South America as an "enlarged economic space²⁶." The difference between such strategies is that while the US sought more specific and detailed agreements with the different countries, Brazil aimed at greater multilateral institutionalization in an attempt to build a regional identity.

The countries on the peaceful shore of the continent, with the exception of Ecuador, agreed to sign bilateral free trade agreements with the United States along the lines of the FTAA, thus making it impossible to incorporate them into Mercosur. As already mentioned, this

²⁶ As President Fernando Henrique Cardoso had declared in the early 1990s.

is the case of Chile, Peru and Colombia. With the implementation of these agreements, import tariffs were immediately zeroed for no less than 80% of U.S. exports of consumer and industrial goods to Peru and Colombia. On these types of products, all remaining Peruvian and Colombian tariffs have been eliminated within ten years. In the case of agricultural goods, more than two-thirds of U.S. exports to Peru and Colombia were immediately free of import tariffs; and most of the remaining tariffs were eliminated in 15 years²⁷ (BATISTA JR., 2008; USTR, 2022). By definition, members of a customs union such as Mercosur, aligned with a TEC, are not free to sign bilateral trade agreements with other countries, in this sense, Colombia, Peru and Chile can only remain as associated members of Mercosur. Such elements reflect a clear tacit competition between the USA and Brazil (TEIXEIRA, 2011).

In August 2004, the U.S. signed the Free Trade Agreement with Central American countries, namely: Dominican Republic, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, called CAFTA-DR. The implementation of the agreement proved to be challenging and occurred continuously after each country made legal, regulatory and general rule changes to comply with the obligations assumed. CAFTA-DR entered into force in July 2006 in El Salvador, Honduras, Nicaragua, and Guatemala. Dominican Republic in March 2007 and Costa Rica in January 2009. The economic logic lies in preferential access to agricultural and manufactured products produced in the region. By removing regional barriers to trade, co-production on shared manufacturing assembly lines between the U.S. and the other CAFTA-DR members was encouraged, based on comparative advantages and economies of scale. The objectives of this agreement included:

- a) To encourage the expansion and diversification of trade between countries; b) To eliminate barriers to trade, and to facilitate the cross-border movement of goods and services between the territories of countries; c) to promote conditions of fair competition in the free trade area; d) substantially increase investment opportunities in the territory of the countries; (e) To provide adequate and effective protection and enforcement of intellectual property rights throughout the territory of each country; f) to create procedures for the implementation and application of the agreement, aiming at its joint administration and for the resolution of disputes, and; g) establish a framework for greater bilateral, regional and multilateral cooperation to enhance the benefits of this agreement (USTR, 2004).

²⁷ Colombia is a major importer of U.S. grains while exporting a number of tropical fruits to the U.S. In addition, U.S. cotton, yarn, and fabric exports to Colombia are used in many clothing items that Colombia exports to the U.S. The main products exported from the U.S. to Colombia that are now exempt from tariffs are: agricultural and construction equipment, aircraft and parts, auto parts, fertilizers and agrochemicals, information technology equipment, medical and scientific equipment, among others. Many agricultural commodities also benefited from the agreement (USTR, 2022).

According to Hornbeck (2012), this strategy increased the productivity of companies in all countries involved. The competitiveness of companies depends on the value added in the supply chain, especially in the apparel sector and, later, extended to the auto parts, medical equipment, integrated circuits, among others. Tariff preferences under CAFTA-DR have contributed to companies remaining competitive given increased competition from Asian countries and other low-cost global producers (IZQUIERDO and TALVI, 2011, p. 42-44 *apud* HORNBECK, 2012). From the point of view of the Central American countries, the permanent reduction of barriers to the U.S. market was the central objective, ensuring that their exports would have access to the large U.S. market and, at the same time, guaranteeing imports at low costs, including intermediate goods and capital goods. In other words, the increase in trade flow could raise the long-term growth rate through various channels, such as: market size, production specialization, economies of scale, technology transfers and managerial experience, use of resources more efficiently, and higher level of investments.

whereas market access is the main element of free trade agreements, and refers to the provisions governing barriers to trade, such as tariffs and import quotas; CAFTA-DR has called for the phasing out of almost all tariffs. For non-textile manufactured goods, the 80% tariffs on imports coming from the US were eliminated immediately, with the remainder being eliminated for a period of up to 10 years. For agricultural products, the 50% tariffs on imports from the US were eliminated immediately, with the rest being eliminated for a period of up to 20 years. For CAFTA-DR member countries, 100% of non-textile and non-agricultural products began to enter the U.S. tariff-free shortly after the agreement was implemented (USTR, 2004). Some "safeguards" were maintained for certain textile and agricultural products during the period of duty elimination, but anti-dumping and countervailing measures were not addressed in the agreement, leaving such trade defense laws to the World Trade Organization.

In order to assess the effects of CAFTA-DR on the countries involved, Hornebeck (2012) proposed a comparative analysis of the period before and after the agreement, demonstrating the main trends in trade in the region in the period between 2000 and 2011. Three main changes stand out: i) the USA remains the largest trading partner among the members, but its relative participation has been reduced to other countries; ii) trade with China and Mexico has increased; and iii) trade between Central American countries increased and deepened.

In 2000, the U.S. was the destination of 73% of the exports and 55% of the origin of imports of CAFTA-DR members, while in 2010 these numbers dropped to 43% and 46%, respectively, the decline occurred in all countries. Between 2000 and 2010, exports to China increased from about 0% to close to 6% and imports from 2% to 7%. Trade among CAFTA-DR members increased from 2 percent to around 11 percent, making the region

the largest in terms of intraregional trade intensity in the U.S. hemisphere. (HORNEBECK, 2012, p. 5).

CAFTA-DR thus plays a supporting rather than a leading role in these new evolving trade patterns, especially in the trend towards greater productive fragmentation and the formation of global value chains. For example, the increase in exports to China is fully represented by Costa Rica's semiconductor exports. The increase in trade between Central American countries is the result of a long-sought effort by countries to deepen subregional integration. In addition, these efforts were strengthened with the signing of the Mexico-Central America free trade agreement in November 2011, which deepened the integration process and increased the volume of trade between the country and the region by four times. This is largely explained by the supply chain relationships that the U.S. and many of its companies have developed in the Mexican economy and in Central America and the Caribbean, particularly in the automotive, apparel, electronics, and computer sectors (HORNBECK, 2012, p. 5-6).

The CAFTA-DR rules of origin reinforce regional integration because they induce greater sharing of production among member countries. This makes the region more competitive globally by increasing co-production relationships, reducing customs delays, and enabling greater economies of scale in production. They also allow tax exemption on imports from the US of products assembled from inputs produced in Central America or Mexico. This relationship is evident in the production of integrated circuits, auto parts and clothing, sectors in which the US sent part of the production chain to this region. This follows the logic of global value chains, in which there is a greater fragmentation of the production chain among several countries in the region, mainly enhancing the trade of intermediate products, parts, components, inputs, and raw materials.

For example, Mexico imports integrated circuits from Costa Rica, apparel from Guatemala, and sets of harness sets for automobiles from Nicaragua, all made from U.S. inputs. These goods are used to assemble computers, clothing and automobiles for export to the U.S. and other Latin American countries. Similarly, fabrics produced in the U.S. are used in apparel production in the Dominican Republic, Honduras, and Guatemala, and final goods are tax-free when they enter the U.S. Thus, unlike commodity-driven export growth, much of the region's trade reflects the global production of the supply chain related to U.S. global production and consumption²⁸ (HORNBECK, 2012, p. 6).

²⁸ It should be noted that the analysis of the technological content of the exports of the CAFTA-DR countries supports the trend of the USA being the largest market for exports of different technological levels. From low-tech apparel to integrated circuits and high-tech medical equipment. Costa Rica's exports from the Dominican Republic have the highest concentration of technological intensity, while Guatemala and Nicaragua have the lowest (HORNBECK, 2012).

Calderón and Poggio (2010) aim to assess the economic growth effects of trade openness among CAFTA-DR countries, and whether these effects are stimulated or hindered by advances in structural policies and institutions. The authors conclude that: although the baseline model predicts the benefits of trade growth for CAFTA-DR countries, not taking into account the complementarities between trade openness and structural factors may overestimate these results. Indeed, the authors point out that human capital, infrastructure development, and institutional quality can play an important role in increasing the benefits of trade growth. In this regard, there is ample room for CAFTA-DR countries to reap the benefits of increased trade, but an important role must be played by new reforms in areas such as education, infrastructure, and international financial integration.

3 DISTRIBUTION OF THE COSTS AND BENEFITS OF THE FTAA – WHO WINS AND WHO LOSES

The American continent is full of large differences in terms of population, level of wealth, volume of production, and per capita income. In this sense, some relevant questions arise, such as: what interests do the US and the Mercosur countries, especially Brazil, have in opening their economies? What are the perceived costs and benefits of hemispheric integration from the point of view of the U.S. and Brazil? Overall, domestic politics in the U.S. and Brazil were what hampered the ability of political leaders and trade policymakers to implement the FTAA. In the U.S., it was the declining traditional sectors (agriculture, textiles, and steel) that most firmly resisted competition from Latin American imports. In Brazil, it was an "entrenched elite" that fears competition in the new commercial sectors (services, investments, high technology) in which the country remains most vulnerable.

3.1 USA – COSTS AND BENEFITS OF THE FTAA

With regard to U.S. interests in the FTAA, the high Mercosur import tariffs (CET) in sectors such as capital goods and high-tech industry products stand out. Considering that the U.S. is competitive in these items, the implementation of the FTAA would generate gains for U.S. investors, through greater access to these markets in the southern cone. In addition, liberalization of government services and procurement as part of FTAA implementation would give U.S. firms the leverage needed to compete with Mercosur-based firms. Finally, another gain involves the issues of intellectual property rights, which are the subject of discussions about the capacity for inspection and, therefore, susceptible to trade sanctions by the USA (MASI and WISE, 2005, p. 320).

The FTAA was also supported by large U.S. companies with investments in Latin America. For these large multinationals, which have been establishing subsidiaries in different countries in the region for a century, by reducing barriers to trade and regulations, there would be greater guarantees for their investments. In addition, it would open up new possibilities for capital to be installed where labor cost conditions were more favorable, as happened with the Mexican maquiladoras after the signing of NAFTA. It would also allow these U.S.-based companies to participate in bids for public works in the areas of health and education²⁹. In this sense, it would put local and foreign investors on an "equal footing" with the only criterion of efficiency, favoring American and Canadian companies (MORGENFELD, 2005, p. 9).

Other sectors favorable to integration were the pharmaceutical industry and biotechnology companies. For these powerful institutions, patent issues are of fundamental importance, as they guarantee intellectual property rights and returns on their investments. This problem is also associated with the privatization process that impacted Latin America in the 1990s and that advanced in all branches of the economy, including sectors and activities that were previously under the state's orbit.

On the other hand, the main arguments in the U.S. against the FTAA resided in labor unions, environmental organizations, and private-sector interest groups, which were considered obsolete or uncompetitive. The agricultural sector and some manufacturers stand out, such as: sugar, tobacco, fruits, vegetables, textiles, footwear and steel, among other products considered more sensitive to integration³⁰. However, although these interest groups are a minority in the US, a new round of protectionism for these products was the one that hit the Mercosur countries the hardest. The bill unilaterally offered access to the U.S. market to the Andean, Central American and Caribbean countries, but not to the Mercosur countries (US DEPARTMENT OF COMMERCE, 2002 p. 4). In other words, the bilateral negotiations between the U.S. and other regional groupings, due to the deadlocks in the FTAA negotiations, granted permanent access to the U.S. market in these sectors considered sensitive, to the detriment of the Mercosur countries, in which there was no pre-existing privileged access. Thus, those in the US viewed the FTAA negotiations with caution were the industrial sectors that produced mainly for the domestic market. They had the perception that they should start to compete more intensely with countries where labor costs were lower.

²⁹ Until then, they were partially forbidden to foreign companies, due to contract clauses or criteria of "buying at the national level".

³⁰ However, some econometric studies reveal that the losses for these sectors under a possible implementation of the FTAA would not be significant, and in some way, there would be net gains with the opening of Mercosur and the other South American countries (ESTEVADEORDAL and ROBERTSON, 2004).

In general, despite intense *lobbying* by several of these interest groups, the perception of most U.S. business associations, including most farmers, is that their gains from the FTAA would outweigh their losses. For example, businessmen from the National Association of Manufacturers (NAM) lobbied then-President Bush for further trade liberalization in the hemisphere, and to do so at a rapid pace. Other associations, which represent American commercial interests, advocated greater market opening for their products in Argentina, Brazil and Chile, and considered these markets to be very promising for exports from the American industrial sector³¹ (MASI and WISE, 2005, p. 320).

One of the main criticisms of the Mercosur countries to the US is related to the high protection of traditional manufactured goods, which fall into the category of "sensitive products", and the high subsidies to agricultural commodities, which contributed to depressing the international prices of these items. If, on the one hand, the U.S. showed great interest in the liberalization of services, investments and government purchases (the new trade issues), on the other hand, the Mercosur countries insisted on the importance of market access to the aforementioned goods as a key condition for the establishment of reciprocal and fair trade. "Mercosur's main exports to the U.S. are agricultural commodities and traditional manufacturing products, mainly agro-industrial goods." (MASI and WISE, 2005, p. 323). Such characteristics reflect the sectors in which the U.S. would gain and those that would lose from continental integration.

3.2 BRAZIL – COSTS AND BENEFITS OF THE FTAA

In Brazil, the country that led the FTAA negotiations from the Southern Cone, different opinions prevailed among businessmen, economic analysts, and policymakers about the implementation of the FTAA. Exporters of agricultural products, companies in the agro-industrial sector and steel and oil producers were in favor of the FTAA and greater trade openness with the US. This support was conditioned by projections of an increase in sales caused by reductions in tariff barriers in the US. On the other hand, companies and entrepreneurs representing other industrial sectors, such as chemicals, automobiles and machinery, did not share this opinion. Members of this second group argued that they would suffer great disadvantages if the Brazilian economy was open to American competition. A key factor that determines the low level of competitiveness for these sectors is the high cost of doing business in Brazil. These include high tax burdens, high interest rates, limited access to venture capital,

³¹ Business sectors such as the American Chemistry Council, the Electronics Industry Alliance, and the High-Tech Goods Coalition acted as a counterweight to the specific sectors that sought to thwart the FTAA.

and a lack of basic and technological infrastructure³². These representatives feared that the FTAA could lead to the dismantling of several sectors and transform the country into an exporter of agricultural commodities (MASI and WISE, 2005, p. 324).

An emblematic case is that of steel. By mid-2001, the U.S. steel industry was operating at 40 percent of its total capacity and was selling steel at the lowest prices in 20 years³³. The government decided to defend its steel industry by raising the tariff on imports to 30%. In order to reverse this U.S. protectionism, Brazilian export sectors have suggested that the trade liberalization project in the Americas could be a good opportunity to negotiate better access to the U.S. market. For these sectors, the FTAA would only make sense if the reduction of such tariffs was negotiated. In this way, they coincide with agricultural exporters, who would be willing to risk a process of greater competition in the domestic market, as long as access to the US market under better conditions was guaranteed (MORGENFELD, 2005, p. 9).

For the large agro-exporting groups in Brazil, the FTAA should not be rejected, but should take advantage of the situation to establish agreements that guarantee a minimum of reciprocity. The argument was that the U.S. should reduce not only tariff barriers, but also non-tariff barriers, since, at the time, 60% of Brazilian exports to that country had some type of non-tariff restriction. For example: "Brazilian orange juice must pay a 56% tariff to access the North American market. Brazil is the largest producer of orange juice in the world [...]. The reduction of tariff and non-tariff barriers would open an important market for Brazilian products." (MORGENFELD, 2005, p. 14). In this way, they supported a free trade area in the Americas, as long as defensive trade practices such as antidumping policies, phytosanitary barriers, or export subsidies were also eliminated continuously and gradually.

On the other hand, industrialists who produced primarily for the domestic market were generally opposed to an FTAA-type agreement. The argument of the Brazilian producers was that certain segments of the local industry were technologically outdated in relation to those of the USA, so that a total and immediate opening could harm national production. One of the biggest opponents of the FTAA's advance was FIESP, which claimed that Brazil would lose one billion dollars a year in its foreign trade if the FTAA came into force in 2006. "For some sectors that were not prepared, the FTAA will be absolutely deadly" said Horácio Lafer Piva, president of FIESP (ADITAL, 2002 *apud* MORGENFELD, 2005, p. 10).

³² Rubens Barbosa, Brazil's Ambassador to Washington until 2004, agreed that Brazil's competitiveness would not be determined solely by preferential tariffs under the FTAA. It would also be necessary to have better coordination between the national public and private sector to reduce the "Brazil cost". The tariff reductions of the FTAA negotiations should be accompanied by a process of strengthening Brazilian competitiveness, also attracting foreign investment in export-oriented and capital-intensive sectors (MASI and WISE, 2005).

³³ As this sector is characterized by high economies of internal scale, such information points to the low American competitiveness of this sector, especially when compared to the Brazilian industry.

Regarding the effects of trade deregulation on Brazilian industry, some studies such as MDIC (2002) and FIESP (2002) divided the analysis into four main groups. The first consists of production chains that would not be negatively affected by the FTAA, and that would also open up commercial opportunities, such as: coffee, pulp and paper, citrus fruits, leather and footwear, steel and part of the textile-clothing chain. In general, these chains are considered more competitive and had trade surpluses from 1996 to 2001. The second group includes chains characterized by significant trade deficits and deficits. These are undifferentiated capital-intensive goods, such as: petrochemicals, processed plastic products and shipbuilding. For this group, studies suggest extreme caution in tariff policy, and it needs to be accompanied by policies to increase competitiveness, in order to accommodate the process of trade liberalization. The third consists of chains in which threats and opportunities counterbalance each other, as is the case of the wood-furniture, ceramics and cosmetics sectors. The former categories had trade surpluses, while the latter had a moderate deficit³⁴. The fourth and final group is made up of chains in which multinational companies have a significant presence, and where intrafirm trade predominates: automakers, pharmaceuticals, communication equipment and electronics. These trade flows strongly depend on the international strategy implemented by the foreign companies that control these chains³⁵ (MACHADO and FERRAZ, 2005, p. 373-375).

Another point of view of this debate was the possibility of increasing Brazil's competitive advantage by enhancing the existing intra-firm trade between the US and the Brazilian economy. As economic theory points out, the regionalization of this type of trade could promote a restructuring based on specialization, economies of scale and technological updating. Certainly U.S. subsidiaries operating in Brazil would benefit greatly from the FTAA, especially in terms of a freer flow of imports from their U.S. headquarters. Such elements could contribute to a higher level of competitiveness of subsidiaries located in Brazil.

[...] the companies that export foreign capital maintain a strong interaction with their headquarters. The companies that registered an increase in their sales and exports between 1995 and 2000 channeled their activities, preferably, to the countries of origin

³⁴ These chains are not sensitive to trade deregulation, but they require precise and selective competitiveness policies. As incentives for product differentiation, for example: development of design and brands in the case of furniture, cosmetics and ceramics, or property and environmental policies as in the case of wood-furniture (MACHADO and FERRAZ, 2005, p. 374).

³⁵ It should be noted that the study points to the importance of national content policies or managed trade, along with policies to support technological development. However, they are insufficient when foreign companies are not willing to negotiate.

of their capital³⁶. [it is thus reaffirmed] the importance of the potential impact of the FTAA: subsidiaries of American and Canadian companies that operate in Brazil have a reasonably diversified geographic structure for their exports, but depend on the US for almost 40% of their imports [...]. [therefore], American transnational corporations tend to export in a greater proportion to countries in which they have a greater participation than to those countries that do not have subsidiaries (BAUMANN and CARNEIRO, 2002, p. 165).

In short, the position of the representatives of the industries in Brazil was not homogeneous. Many São Paulo industrialists supported the deepening of the link with the USA. The position of one or the other depended on their chances of survival if the FTAA project went ahead. Such attitudes varied not only according to each sector of the economy, but also according to the size of the companies, and according to the degree of concentration and centralization of capital that each of them presented. In any case, most studies on the possible impacts of the liberalization of the economy, which provided the basis for these positions, showed that Brazil would end up importing much more than it could export. Even considering that tariffs would be zeroed in all American countries, many of these representatives viewed the progress of the FTAA negotiations with suspicion or fear, which partly explains the Brazilian government's position of being more reluctant to agree with the United States (MORGENFELD, 2005, p. 10). By way of conclusion of this article, Table 01 presents a synthesis of the distribution of the costs and benefits of the FTAA for the USA and Brazil.

Table 1

Distribution of the Costs and Benefits of the FTAA

	Who would win	Undefined	Who would lose
USA	Capital goods sector: machinery	Intra-industry trade: oil.	Agro-industrial sector: sugar, tobacco, vegetables, fruits, orange juice, etc.
	High-tech industry: biotechnology, electronics etc.	Sector: wood-furniture, ceramics and cosmetics.	Manufacturers: textile-clothing, footwear, pulp and paper, and steel.
	Chemical and pharmaceutical industry		
	Service sector		
Brazil	Who would win	Undefined	Who would lose
	Agro-industrial sector: coffee, sugar, tobacco, vegetables,	Trade led by multinationals: automakers,	Capital goods sector: machinery

³⁶ According to the authors, there are intra-firm transactions that could influence the estimates of the effects associated with preferential trade agreements. This could generate a sectoral distribution different from that obtained in the estimates of trade creation and trade diversion derived from a tariff reduction.

	fruits, orange juice, etc.	communication equipment and electronics.	
	Manufacturers: textiles and clothing, pulp and paper, footwear, steel, petroleum.	Sector: wood-furniture, ceramics and cosmetics.	Chemical and petrochemical industry, processed plastics, shipbuilding and pharmaceuticals.

Source: Prepared by the authors.

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MODERN TECHNIQUES IN MACHINE LEARNING WITH IMAGES

MODERNAS TÉCNICAS NO APRENDIZADO DE MÁQUINA COM IMAGENS

TÉCNICAS MODERNAS EN EL APRENDIZAJE AUTOMÁTICO CON IMÁGENES



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ABSTRACT

This chapter presents modern Machine Learning techniques applied to computer vision, divided into two complementary fronts: the processing of 2D images and videos and the classification of three-dimensional data (3D images). The first has strong applications in security and product sales, while the second is fundamental for areas such as the parts manufacturing industry and medical image processing. Thus, the first part of the chapter explores the practical use of the YOLO ecosystem (specifically YOLO26) for object detection and scene classification, covering the implementation of inference pipelines, data annotation, fine-tuning, and data augmentation techniques to mitigate training overfitting. In the second part of the chapter, the focus is on the challenges involved in processing 3D spaces, detailing geometric representation processes (meshes, point clouds, and voxel grids). The chapter also presents the construction and preprocessing of a volumetric classifier from scratch, using the ResNet3D-18 architecture on the ModelNet10 dataset, along with a critical analysis of the model's performance.

Keywords: Computer Vision. Machine Learning. Detection and Classification. Video. 3D Images.

RESUMO

Este capítulo apresenta técnicas modernas de Aprendizado de Máquina aplicadas à visão computacional, dividindo-se em duas frentes complementares: o processamento de imagens e vídeos 2D e a classificação de dados tridimensionais (imagens 3D). A primeira, encontra forte aplicação em segurança e em vendas de produtos e, o segundo, fundamental para, por exemplo, a indústria de peças e o tratamento de imagens médicas. Desse modo, a primeira parte do capítulo explora o uso prático do ecossistema YOLO (especificamente o YOLO26) para detecção de objetos e classificação de cenas, abrangendo a implementação de pipelines de inferência, anotação de dados, fine-tuning e técnicas de data augmentation para

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mitigar sobreajustes do treinamento. Na segunda parte do capítulo, o foco é sobre os desafios no tratamento de espaços 3D, detalhando os processos de representação geométrica (malhas, nuvens de pontos e grades de voxels). Apresenta-se aqui a construção e o pré-processamento de um classificador volumétrico do zero, utilizando a arquitetura ResNet3D-18 sobre o dataset ModelNet10, com uma análise crítica do desempenho do modelo.

Palavras-chave: Visão Computacional. Aprendizado de Máquina. Detecção e Classificação. Vídeo. Imagens 3D.

RESUMEN

Este capítulo presenta técnicas modernas de Aprendizaje Automático aplicadas a la visión por computadora, dividiéndose en dos frentes complementarios: el procesamiento de imágenes y videos 2D y la clasificación de datos tridimensionales (imágenes 3D). La primera tiene una fuerte aplicación en seguridad y en la venta de productos, mientras que la segunda es fundamental para, por ejemplo, la industria de piezas y el tratamiento de imágenes médicas. De este modo, la primera parte del capítulo explora el uso práctico del ecosistema YOLO (específicamente YOLO26) para la detección de objetos y la clasificación de escenas, abarcando la implementación de pipelines de inferencia, anotación de datos, fine-tuning y técnicas de aumento de datos para mitigar el sobreajuste durante el entrenamiento. En la segunda parte del capítulo, el enfoque se centra en los desafíos relacionados con el tratamiento de espacios 3D, detallando los procesos de representación geométrica (mallas, nubes de puntos y rejillas de vóxeles). También se presenta la construcción y el preprocesamiento de un clasificador volumétrico desde cero, utilizando la arquitectura ResNet3D-18 sobre el conjunto de datos ModelNet10, junto con un análisis crítico del desempeño del modelo.

Palabras clave: Visión por Computadora. Aprendizaje Automático. Detección y Clasificación. Video. Imágenes 3D.

1 INTRODUCTION

In the current scenario of computer vision, Machine Learning models based on deep convolutional neural networks (CNNs) almost completely predominate today [Bhatt et al. 2021]. But the transition from theory to successful real-world application of these models—such as analyzing *in-the-wild* videos—or processing geometries from industrial parts and medical examinations—requires more than just instantiating a basic architecture. It requires mastery of complementary techniques and robust workflows.

This chapter introduces the main concepts, provides intuition, and provides a *practical pipeline* of these modern techniques, as a starting point for the student or researcher who needs to use these techniques in a real problem or research project. We initially explore the state of the art in efficient (fast) image processing using the YOLO26 [Ultralytics 2026] ecosystem for images, demonstrating how to apply pre-trained models, specialize them for new data, and make them resilient to variations in the environment. Next, we extend the two-dimensional grid of 2D images to the processing of three-dimensional images in spatial models. From the ModelNet10 dataset [Wu et al. 2015], we illustrate the preprocessing pipeline required by 3D data and the adaptation of CNNs to operate over spatial volumes with ResNet3D-18 networks [Hara et al. 2018].

All the codes and materials used in this chapter can be found in the <https://github.com/Capitulo-Aprendizado-de-Maquina-Imagens/>.github repository. They are an integral part of this chapter and it is recommended that the reader access this material in addition to the reading of the chapter.

2 YOLO AND IMAGE AND VIDEO PROCESSING

Introduced in 2015 by Joseph Redmon and his team, YOLO (*You Only Look Once*) brought a revolutionary approach to computer vision based on Convolutional Neural Networks (CNNs) [Redmon et al. 2016]. Instead of slicing the image and analyzing it into multiple cutouts like the classic models, YOLO applies a single neural network over the entire image at once. It divides the scene into a mathematical grid and simultaneously predicts where the objects are. In the most widely used detection models, this is done by means of bounding *boxes* that calculate the probability of each class.

This "single look" enabled real-time detection, a critical factor for video processing. In general terms, a video is a set of several images in sequence. These images, or frames, are called *frames*. Since a typical video runs between 30 and 60 *frames* per second (FPS), slow models generate high latency and "choke" processing. YOLO's optimized architecture allows it

to process tens of *frames* per second, making it possible to analyze *in-the-wild* videos (from the real world, without positioning or lighting control), following objects as the scene unfolds.

To achieve this efficiency, YOLO models are already pre-trained on the COCO (*Common Objects in Context*) dataset, a gigantic dataset, widely used by the AI community containing more than 330,000 annotated images with everyday objects divided into 80 categories or classes (such as cars, people, dogs, chairs, bottles, etc.) [Lin et al. 2014]. In other words, the model is born with a robust base for extracting characteristics, knowing the basic world.

2.1 YOLO ECOSYSTEM

The original architecture has evolved and today the YOLO family is an ecosystem capable of solving different computer vision problems, each with its own specialty. Table 1 summarizes how the network "sees" according to the chosen model.

It is important to note that advances in computer vision occur at a very accelerated pace and it is possible that by the time you are reading this chapter there are already newer models of YOLO available. Don't worry, the codes are all adaptable for use by any existing template.

Table 1

Comparison of YOLO26 models, main functions and ways of viewing.

Model	Main Function	How the network "sees"
YOLO26-clc	Classification	Evaluates the entire image and indicates which class predominates in the scene.
YOLO26	Object Detection	Answers what the object is and where it is, drawing bounding <i>boxes</i> .
YOLO26-sec	Instance Segmentation	Draws the exact outline of the object found, pixel by pixel.
YOLO26-pose	Pose Estimation	It identifies key points, focusing on structure and movement, such as human joints.
YOLO26-obb	Guided Detection	Draws rotated boxes, useful for aerial images where objects appear at varying angles.

In Table 1 we have seen five models and their applications. For the practical scope of this chapter, which is focused on extracting relevant information from real-world videos and generating an intuition about how YOLO works, we will explore the two fundamental models: the Classifier (YOLO26-clc) and the Detector (YOLO26).

2.2 AN INFERENCE PIPELINE WITH YOLO

The practical application of YOLO models follows a unified workflow, often using the official Ultralytics library [Ultralytics 2026]. The steps consist of instantiating the model, loading the video, and performing inference.

2.2.1 Example: Classifier, YOLO26-clb

Since this is a classifier model, it only tells you what's being found in the entire *frame*, i.e., it doesn't specify where the object is being found.

Code 2.1 is a simple example of implementing and using the classifier model directly on any video. You can access the directory of that project in the GitHub repository and run it on your machine locally using any video on your computer. A sample video can be found in the project directory.

Table 1

Code 2.1. Basic inference pipeline using the classifier model YOLO26n-clb

```
from ultralytics import YOLO

#1. Instantiate the pretrained model model = YOLO('yolo26n-clb.pt')
# 2. Upload the video (replace the file path below)
results = model(source=r'C:\caminho_do_video\video_exemplo.mp4',
show=True, stream= True)

#3. Inferencia for frame in resultados:
# Returns the overall probability of the scene print(frame.probs.top1)
#**IMPORTANT**: To finish the video press the "Q" key.
```

Figure 2 demonstrates how the classification model runs, showing the probability of the classes in the upper left corner.

Figure 2

Example of video running with the ranking model



2.2.2 Example: Detector, YOLO26

With the detector model, the boxes point to the multiple objects within each frame of the video, which can be more interesting if the challenge is to know where the object is in the scene.

Using the same Code 2.1, let's adapt lines 4 and 13, calling the detector model and adding the *bounding boxes*, as we see in Code 2.2.

Table 2

Code 2.2. Basic inference pipeline using the YOLO26n detector model

```
from ultralytics import YOLO
#1. Instantiate the pretrained model (changed to the detector) model =
YOLO('yolo26n.pt')
# 2. Upload the video (replace the file path below)
results = model(source='C:\caminho_do_video\video_exemplo.mp4',
show=True, stream= True)
#3. Inferencia for frame in resultados:
# Returns the bounding box of the print(frame.bboxes.xyxy) object
##IMPORTANT##: To finish the video press the "Q" key.
```

Figure 3 shows how a detector model behaves, finding the objects and drawing the *bounding boxes* in the scene.

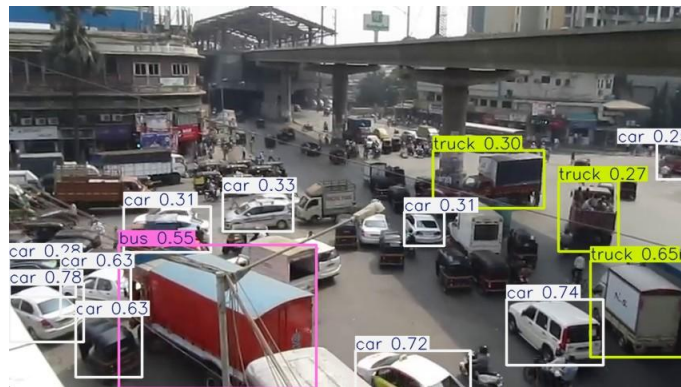
That's it, you've just applied two computer vision models and you can follow how they work along with the video!

2.3 FINE-TUNING AND DATA PREPARATION

Fine-tuning is a technique that allows you to take advantage of the knowledge base acquired in the COCO dataset to teach new categories specific to YOLO. When we do this, there is a transfer of knowledge, but the original classes are lost. This means that when we apply *fine-tuning* we use the knowledge of the neural network, but specify it for the new classes or categories that we want our model to recognize. As a result, the way you prepare this data and train the neural network changes drastically depending on your goal: classifying the entire image in the scene or detecting specific objects within it.

Figure 3

Example of video running with the detection model



2.3.1 Classification Flow

In classification tasks, the neural network learns what an object is through images separated into categories.

i. Dataset Structure

Preparing data for classification does not require manual markings on the image. The very organization of the folders defines the classes. The industry standard is to perform a *split* (manual division of the data) separating it into Training, Validation and Testing, usually in a ratio of 80% for training and 20% for validation and testing, or 70/20/10 depending on the total volume.

Figure 4 shows the directory structure and hierarchy required by YOLO for classifier training.

ii. Training and Evaluation

With folders organized, training only requires the model to point to the main directory. In addition, it is at this stage that YOLO itself applies *Data Augmentation techniques* under the hood (such as rotations and brightness variations) to prevent the network from "decorating" the images. By default YOLO does this automatically, but it is possible to adjust the *Augmentation* parameters, as we will explain in section 1.6.

Code 2.3 shows how to train a classifier model with 50 epochs, 224px image size, and a batch of 16 simultaneously processed images. As training a neural network is a costly task for a standard computer, we recommend that *fine-tuning* be done in Google's Colab tool, where there are options to select environments more suitable for training neural networks (with options that use T4 or A100 GPUs). These environments will bring a higher training speed to your computer vision projects with images.

Figure 4

Recommended Directory Structure for Classification Model Training

```
meu_dataset_classificacao/
├── train/
│   ├── cachorro/ (contém 70% de
│   │             imagens de cachorros)
│   └── gato/ (contém 70% de
│             imagens de gatos)
├── val/
│   ├── cachorro/
│   └── gato/
└── test/
    ├── cachorro/
    └── gato/
```

Table 3

Code 2.3. Fine tuning of classification model

```
from ultralytics import YOLO
# Loads pre-trained classification model = YOLO('yolo26n-cls.pt')
#      Start      training      results      =      model.train(
data=r'caminho_do_dataset_classificacao', # Root folder with train/val/test
epochs=50, # Number of times the network will see the entire dataset
imgsz=224, # Image size for sorting batch=16      # Batch of images
processed simultaneously)
```

To evaluate the classifier model, we observed the drop in the *Loss Function* (which measures the mathematical error of the network), as the drop increases in each iteration, we understand that the model is converging. In addition, we track accuracy (Top-1 and Top-5), which indicates the percentage of times the network has registered the correct class. In this case, the higher the accuracy, the more correct answers the model recorded.

2.3.2 The Detection Flow

When we need to find the exact location of something in a scene, folders alone are not enough. In the case of detector models, we need to teach the coordinates of objects to the network.

i. *Annotation, Roboflow*

For detection, each image must be accompanied by a text file containing the coordinates of the bounding *boxes*. The legwork of drawing these boxes is called *Annotation*, and platforms

like Roboflow simplify this process. In the interface, we draw a very tight rectangle around the object, associate it with a class and the tool exports the dataset already structured and divided.

Figure 5 illustrates the annotation process on the platform. After the object is selected, the class name is entered.

ii. Training and Evaluation

Unlike the classifier that reads folders, the detector uses a data.yaml configuration file generated during annotation to locate the images and their labels. Code 2.4 shows how to *fine-tune* a model. Note that the main difference is that the dataset is referenced with the data.yaml file. In addition, detector models are usually more expensive than classifiers and their training can take longer, mainly because they require higher resolutions in training.

Figure 5

Example of annotation on the Roboflow platform

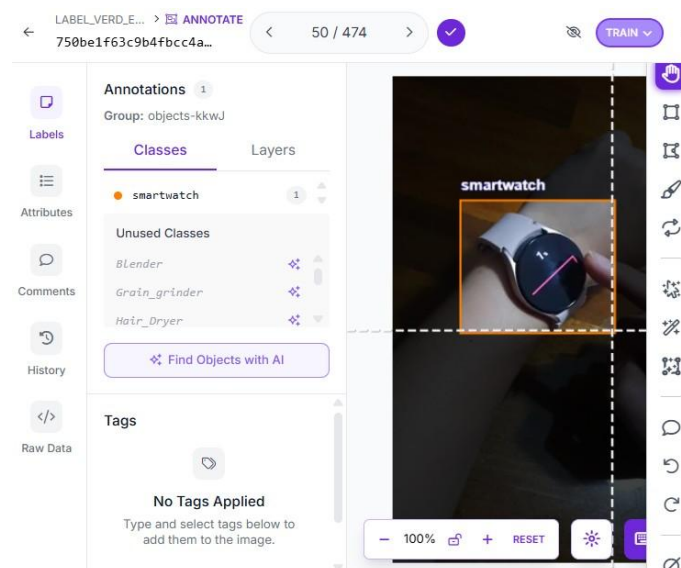


Table 4

Code 2.4. Fine tuning of Detection model

```
from ultralytics import YOLO
# Loads the pre-trained detection model = YOLO('yolo26n.pt')
# Start training results = model.train( data='path/data.yaml', # File
generated in annotation epochs=50, imgsz=640, # Detectors require higher
resolutions batch=16)
```


In detection, in addition *to the Loss Function*, the main evaluation metric is mAP (*Mean Average Precision*). mAP simultaneously evaluates whether the model has hit the class and whether the box it draws correctly overlaps the real object (another metric known as *Intersection over Union* - IoU).

2.4 DATA AUGMENTATION

One of the biggest challenges in machine learning is *overfitting*, which occurs when the model becomes an expert at recognizing only the exact images of its training set, but fails miserably when finding the same object at a different angle or under a shadow in the real world.

To mitigate this, we use *Data Augmentation*. This technique consists of applying random mathematical transformations to the original images during the training process, creating infinite variations without having to take new photos or make new notes [Géron 2019].

2.4.1 Types of *Data Augmentation*

There are numerous possibilities for increasing data, but we will address the most common ones in this subsection.

- Geometric Transformations: Flips, rotations, and zooms. This teaches the model that a product upside down or seen from afar remains the same product.
- Color Transformations: Changes in brightness, contrast, and saturation. Essential for *in-the-wild* videos, where lighting is not controlled like in a studio.
- Quality Filters: Addition of Gaussian noise or blur. This prepares the network to handle low-resolution cameras or fast movements that blur the frame.

2.4.2 Implementation in YOLO

The Ultralytics library already includes native *augmentation* settings that are automatically applied during *fine-tuning* of a model. However, we can customize the intensity of these transformations directly in the hyperparameters of the `train()` command.

In your training code, you can add the parameters from Code 2.5 to make the model more resilient.

Table 5**Code 2.5. Custom Data Augmentation Application Example**

```
# Example of fine-tuning with augmentation parameterization
results=model.train( data='data.yaml', epochs=50, degrees=15.0, # Rotates
the image up to 15 degrees flipud=0.5, # 50% chance to rotate the image
vertically brightness=0.3, # Varies brightness by up to 30%
blur=0.1, # Applies random blur to simulate motion device=0)
```

This technique is what allows your model to detect products in a video from a supermarket aisle or on a traffic camera, even if the camera is swaying or the light is blown out in some spots.

2.5 APPLYING THE CUSTOM MODEL

After training (both a classification and detection model), YOLO automatically saves a copy of the network's best moment, often referred to as best.pt.

To apply this newly acquired knowledge in the real world, we went back to the inference pipeline seen in 1.4 and adapted in Code 2.6. The only difference is that instead of loading the factory model from Ultralytics, we load our file.

Table 6**Code 2.6. Inference with trained models**

```
from ultralytics import YOLO
# We replaced the original model with our newly trained model
modelo_customizado = YOLO(r'C:\caminho_do_modelo_treinado\best.pt')
# We apply it to real-world video
results =
modelo_customizado(source=r'C:\caminho_do_video\video_exemplo.mp4',
show=
True, stream=True)
for frame in results:
    print(frame.bboxes.xyxy) # For detection #print(frame.probs.top1) # For
classification
```

2.6 NEXT STEPS WITH YOLO

Throughout these sections you have seen how YOLO26 simplifies and powers computer vision projects, from model loading to specialization and practical application in videos. Despite its innovations and efficiency, it is important to remember that, like any technology, YOLO26 can present limitations in very specific scenarios or highly specialized tasks, requiring adjustments or complementary solutions. Still, its modern architecture and ease of use open doors to innovative applications, making you able to explore new possibilities and create increasingly intelligent and impactful solutions.

3 3D IMAGE CLASSIFICATION

So far we have worked with images and videos, that is, with data organized in 2D pixel grids. But a growing share of modern computer vision applications must deal with objects in three-dimensional space: CT scans and MRIs in the medical field, industrial parts scanned for quality control, environments captured by LiDAR sensors in self-driving cars, and CAD models used in engineering and architecture. In all these cases, "flattening" the data in a single photo means losing the very information that matters: the shape of the object in space.

For this kind of problem, we need models that see in three dimensions. In this section we will build a 3D object classifier using the ResNet3D-18 architecture on top of the ModelNet10 dataset, a classic benchmark containing CAD models of everyday furniture and objects [Wu et al. 2015]. The path we are going to take involves an extra step that does not exist in the 2D world: before reaching the neural network, the 3D data needs to be converted into a format that CNN can process. It is precisely this pre-processing — transforming a mesh of triangles into a grid of voxels — that occupies a good part of our pipeline.

3.1 3D REPRESENTATIONS

There are three main ways to represent a three-dimensional object on the computer, each with advantages and disadvantages:

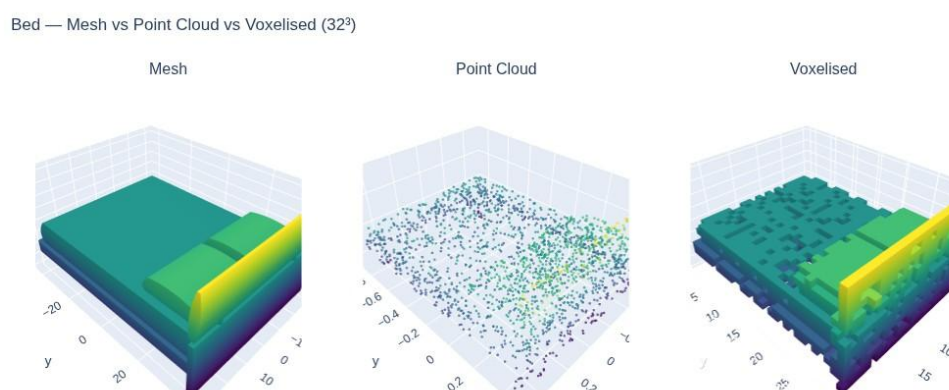
- **Mesh:** The object is described by vertices (points) connected by triangular faces. It is the native format of 3D modeling software and .off, .obj, and .stl files. Compact and precise, yet irregular — each model has a different number of vertices and faces.
- **Point *cloud*:** The object is represented only by the coordinates (x,y,z) of points on its surface, with no connectivity information. It is the natural output format of LiDAR sensors and 3D scanners.

- **Voxel grid:** space is divided into small cubes (the "3D pixels") and each cube receives the value 1 if it contains the object's surface and 0 if it is empty. It is the closest representation to a digital image, and precisely for this reason it is the one that fits directly into a CNN.

Figure 3.5 illustrates these three representations for the same ModelNet10 object. Notice how the mesh preserves fine details with little data, the point cloud samples the unstructured surface, and the voxel grid "pixelizes" the object into a regular cube.

Figure 6

Comparison between mesh, point cloud and voxel grid for the same ModelNet10 3D model



The choice of representation determines the type of neural network we can use. Networks that operate directly over point clouds, such as PointNet, exist and are quite powerful, but they require special architectures. For classifiers based on conventional CNNs, the most direct path is what the literature calls a volumetric approach: voxelizing the object and treating the resulting cube as a "3D image" [Maturana and Scherer 2015]. That is the approach we will take here.

3.2 THE MODELNET10 DATASET

ModelNet10 is a subset of the ModelNet project, launched by Princeton University in 2015 [Wu et al. 2015]. It brings together about 5,000 clean and aligned CAD models, distributed in 10 categories of furniture and household objects: bathtub, bed, chair, desk, dresser, monitor, bedside table, sofa, table and toilet. Because of its manageable scale and balance between classes, it is often called the "MNIST of 3D" — a didactic benchmark before moving on to larger datasets such as ModelNet40 or ShapeNet.

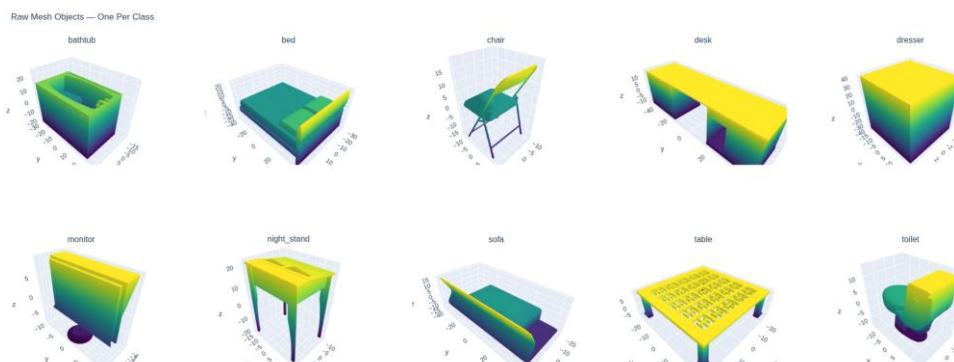
Each model is stored in OFF (*Object File Format*) format, a plain text file: the first line is the OFF header, followed by the vertex, face, and edge counters. Then come the coordinates of each vertex and, finally, the definition of each triangular face, indicating which vertices compose it.

The dataset already comes with the division between training and test ready, organized into subfolders by class (one train/ and one test/ folder within each category). Since there is no separate validation folder, the validation split is done from the training set before training. The big difference in relation to the 2D case seen so far is the content of the files: instead of .jpg images or .png ready to be fed to the network, we have meshes that need to be processed.

Figure 3.6 shows an example of each of the 10 classes in the dataset, rendered from the original .off meshes. Notice the variety of geometries: thin-walled objects (chair, table), massive volumes (dresser, monitor), shapes with cavities (bathtub, toilet) and flat tops on supports (table, desk). This diversity explains why some classes will be easy for the network to learn and others not so much—we'll come back to this point in error analysis.

Figure 7

One example per ModelNet10 class, rendered directly from the original .off meshes. The colors encode the height (z) of each vertex



3.3 MESH AND VOXEL: 3D DATA PREPROCESSING

As we have seen, a mesh cannot be fed directly to a CNN: the number of vertices varies from model to model, and the network expects a fixed-size input arranged in a regular grid. We then need a pre-processing pipeline that converts the mesh into a grid of voxels with standardized resolution. This pipeline has three steps: point-on-surface sampling, normalization, and voxelization.

3.3.1 Surface Point Sampling

The first step is to generate a point cloud from the mesh, with a fixed number of points for all models (in our case, 3,000). The naïve way to do this would be to choose vertices at random, but this would pose a problem: regions with many small triangles would be overrepresented, while large, flat regions would be almost empty.

The solution is area-weighted sampling: we draw triangles with probability proportional to their area, and for each triangle chosen, we generate a random point within it using barycentric coordinates. This ensures even coverage of the surface, regardless of how it has been tessellated.

3.3.2 Standardisation

CAD models come in arbitrary scales and positions—one can be centered at the origin with 1 unit in height, another offset, and with 100 units. In order for the network to learn the shape of the object and not its absolute scale, we normalize the point cloud to fit into a unit cube: we subtract the minimum from each axis (so the box starts at the origin) and divide it by the longest length (so the largest dimension becomes 1.0).

3.3.3 Voxelization

With the cloud normalized to $[0, 1]^3$, the voxelization itself is straightforward. We define a resolution R (e.g., 32 voxels per edge) and map each point (x, y, z) to an integer index (i, j, k) by multiplying its coordinates by $R-1$ and rounding. We mark each cell visited with 1.0 and leave the others at 0.0. The result is an *occupancy grid*: a binary cube where 1 indicates the presence of a surface and 0 indicates empty space.

Code 3.7 shows the implementation of this final step: the inputs are a point cloud $(N, 3)$ and the desired resolution, and the output is a *numpy array* (R, R, R) ready to be stacked in batches and sent to the network. The logic is simple — multiply the coordinates by $R-1$, round to integer, and mark each cell visited with 1.0.

Table 7

Code 3.7. Voxelization of a point cloud into a fixed-resolution occupancy grid.

```
def voxelize_point_cloud(points, resolution):
    """Converts a cloud (N, 3) into a binary voxel grid (R, R, R).""" grid =
np.zeros((resolution, resolution, resolution), dtype=np.
float32)
    if points.shape[0] == 0:
        return grid
    #1. Translated to the origin (each axis starts at 0) shifted = points -
points.min(axis=0)
    #2. Scale to fit [0, 1]^3 (largest dimension = 1.0) max_extent =
float(shifted.max()) if max_extent == 0.0:
        Return Grid # Degenerate Cloud (All Points Equal)
        normalized = shifted / max_extent
    #3. Quantizes on integer indexes and marks occupied cells indexes =
(normalized * (resolution - 1)).astype(np.int32) indexes = np.clip(indexes, 0,
resolution - 1)
    grid[indexes[:, 0], indexes[:, 1], indexes[:, 2]] = 1.0 return grid
```

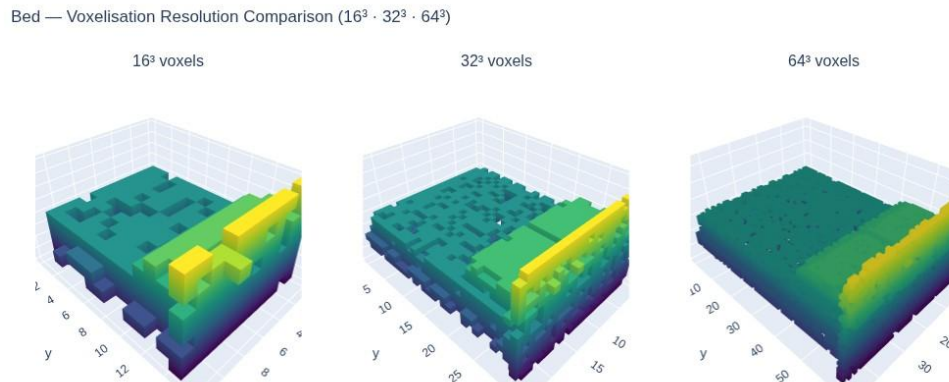
3.4 THE RESOLUTION TRADE-OFF

The grid resolution is the most important hyperparameter of this step, and it involves a *severe tradeoff*. With $R = 16$, each model fits in only $16^3 = 4.096$ voxels — quick to process, but fine details (chair legs, table legs) may disappear. With $R = 64$, we gain $64^3 = 262.144$ voxels is much more detail, but memory consumption and training time increase in $O(R^3)$. Doubling the resolution multiplies the cost by eight.

Figure 3.7 shows the same voxelized object at three different resolutions. For ModelNet10, values between 323 and 643 are the most common equilibrium point in the literature [Maturana and Scherer 2015]. In the rest of this chapter we will use 323, enough to distinguish the 10 classes of the dataset with good accuracy on modest hardware.

Figure 8

The same object voxelized in three resolutions: 163, 323 and 643. Higher resolutions preserve more geometric detail at the cost of more memory and processing time.



3.5 THE RESNET3D-18 ARCHITECTURE

With the data ready in volumetric format, we now need a neural network that operates on voxel cubes in the same way that a conventional CNN operates on images. The choice here is ResNet3D-18, a three-dimensional version of the classic ResNet by He et al. [He et al. 2016]. Before explaining the adaptation, it's worth a quick pause on what makes ResNet special.

Before ResNet, very deep networks were difficult to train — after a certain number of layers, the gradient that walks back during backpropagation became so small that the first layers practically stopped learning (the famous *vanishing gradient* problem). ResNet solved this with a simple idea: instead of each layer block calculating an output from scratch, it only calculates the *difference* (the waste) in relation to the input, and that input is added to the result via a *skip connection*. This shortcut creates a direct path to the gradient, allowing you to train networks with 18, 50, or even 152 layers without degradation.

ResNet-18 is the lightest variant in the family, with 18 layers and about 11 million parameters. It's the natural choice when we have a modestly sized dataset like ModelNet10 — larger networks would tend to overfit with no real gain in accuracy.

3.5.1 From 2D to 3D: Swapping the *Kernels*

The transition from a 2D CNN to a 3D one is conceptually straightforward: where there was a 2D operation (convolution, *pooling*, *batch normalization*), we exchange it for the 3D equivalent.

In code, it's literally swapping Conv2d for Conv3d, MaxPool2d for MaxPool3d, and so on. What changes is the shape of the *kernel*: instead of a 3×3-type 2D window that slides across the image, we have a 3×3×3 3D window that slides across the voxel cube, capturing geometric patterns in all directions simultaneously.

Table 8 summarizes the ResNet3D-18 architecture that we will use. At each *stage* (layer1 to layer4) the cube is halved in each dimension and the number of channels doubles — the same pyramidal pattern as in 2D ResNets. In the end, the *global average pooling* collapses cube 2×2×2 into a single 512 feature vector, which is then projected into 10 values (one probability for each class of ModelNet10).

Table 8

Layers of ResNet3D-18 adapted for ModelNet10. B is the lot size, and D = H = W = 32 is the voxel resolution

Camada	Operação	Saída
Entrada	Cubo de voxels	$(B, 1, 32, 32, 32)$
stem	Conv3d + BN + ReLU	$(B, 64, 16, 16, 16)$
layer1	2 blocos residuais	$(B, 64, 16, 16, 16)$
layer2	2 blocos residuais (<i>stride</i> 2)	$(B, 128, 8, 8, 8)$
layer3	2 blocos residuais (<i>stride</i> 2)	$(B, 256, 4, 4, 4)$
layer4	2 blocos residuais (<i>stride</i> 2)	$(B, 512, 2, 2, 2)$
avgpool	<i>Average pooling</i> global	$(B, 512)$
fc	Linear → 10 classes	$(B, 10)$

3.5.2 Adapting the *torchvision* model

PyTorch already offers a ready-made implementation of ResNet3D-18 through the `torchvision.models.video.r3d_18` function. The name of the module (*video*) indicates the origin of the model: it was originally proposed for recognition of actions in videos, where the third dimension is time [Tran et al. 2018]. Despite this temporal origin, architecture is purely spatial — nothing in it is time-specific — and it works equally well when the third dimension is a spatial coordinate, as in our case. To use the model in ModelNet10 we need to make only two adjustments:

- Input layer (**stem[0]**): the original version expects 3 channels (R, G, B of the video). Our voxel grids only have 1 channel (busy/empty), so we swapped the first convolution to accept 1 input channel.
- End layer (**fc**): The original version classifies into 400 actions of the Kinetics dataset. We swapped it out for a Linear layer (512, 10) to produce the 10 classes of ModelNet10.

Code 3.8 shows this adaptation in *PyTorch*. Notice how minimalist it is: we instantiate the *torchvision* model without pre-trained weights (`weights=None`), replace the first convolution

preserving the other hyperparameters (*kernel*, *stride*, *padding*), and swap the final fully connected layer. Everything else in the architecture—the four *stages* of residual blocks, the *global average pooling*—is repurposed directly.

Table 9

Code 3.8. Adapted torchvision's ResNet3D-18 for 1-channel, 10-class input.

```
import torch.nn as nn import torchvision
def build_resnet3d18_classifier(num_classes, in_channels=1):
    """ResNet3D-18 adapted for 1-channel volumetric input.""" model =
    torchvision.models.video.r3d_18(weights=None)
    # 1. Replaces the first convolution: 3 channels (RGB) -> 1 channel (voxel)
    original_conv = model.stem[0] model.stem[0] = nn.Conv3d(
    in_channels=in_channels, out_channels=original_conv.out_channels,
    kernel_size=original_conv.kernel_size, stride=original_conv.stride,
    padding=original_conv.padding, bias=False,
    )
    #2. Replaces the final layer: 400 actions (Kinetics) -> num_classes
    in_features = model.fc.in_features model.fc = nn.Linear(in_features,
    num_classes) return model
    model = build_resnet3d18_classifier(num_classes=10, in_channels=1)
```

It is worth noting that we are training the model from scratch, that is, without carrying pre-trained weights — unlike what was done with YOLO at the beginning of this chapter. For a dataset with the simplicity of ModelNet10 (only 10 balanced classes, with very different geometries), training from scratch achieves decent results in a few epochs, without the need for the prior knowledge that pre-training would bring.

3.6 3D CLASSIFIER TRAINING PIPELINE

With the pre-processing and architecture defined, it remains to integrate everything into a training pipeline. Unlike YOLO — which has a high-level API where you just point to a folder and call `model.train()` — here we use *PyTorch* directly, which gives you more control over each step of the process.

3.6.1 Dataset and DataLoader

PyTorch organizes training data around two abstractions: the Dataset, which knows how to load an individual sample, and the DataLoader, which groups samples into batches and delivers them to the training loop. For ModelNet10, the Dataset encapsulates the entire pipeline from the previous section: it takes the path of an .off file, reads the mesh, samples the points, normalizes the cloud, and voxels it, returning the voxel cube in the format $(1, R, R, R)$ along with the entire class label.

3.6.2 Data Augmentation in 3D

Section 1.6 introduced *data augmentation* in the 2D context, with transformations such as rotations, *flips*, and brightness variations. In 3D, the idea is the same — to apply random geometric transformations so that the network doesn't memorize the exact poses of the workout — but the transformations themselves are different, and not all ideas from the 2D world make sense here.

The most important difference involves the vertical axis. The ModelNet10 models are all aligned upright: the Z-axis points upwards consistently across the entire dataset. This means that:

- Rotation on the Z axis is safe: Rotating a chair around the vertical axis produces another valid chair — it's equivalent to looking at the same object from another angle, simulating cameras positioned in different directions around the object.
- Rotation on the X or Y axes is risky: Turning a chair upside down produces a scene that the network will never see in the real world, and can confuse the model during training.

In addition to rotation, we added a bit of Gaussian noise to the coordinates of the points before voxelization, simulating small scanning imperfections and making the network more robust to noisy real-world data. These two transformations are applied before voxelization, still in the point cloud.

Like any form of *augmentation*, they are only applied to the training set, never to the test — we want to evaluate the model on "clean" data that reflects the actual expected performance. Code 3.9 shows the implementation of these two transformations.

3.6.3 Training

With data, model, and *augmentation* ready, the training follows the classic *PyTorch pattern*: each season, the model goes through all the batches of the training set, calculates the error between its predictions and the actual labels with the *cross-entropy*, and updates its

weights with the Adam optimizer. Each season we measure the accuracy in the test set and save the model if it beats the previous best result — this strategy ensures that the final evaluation is always done with the best weights, and not with those of the last season.

On modest hardware (Google Colab's GPU T4), the full ModelNet10 training at 323 resolution takes between 15 and 30 minutes for 10 epochs, achieving about 83% accuracy in the test set. The training curves in Figure 9 show this behavior: the *loss* drops consistently at each epoch, while the validation accuracy stabilizes around 82% around the 5th epoch.

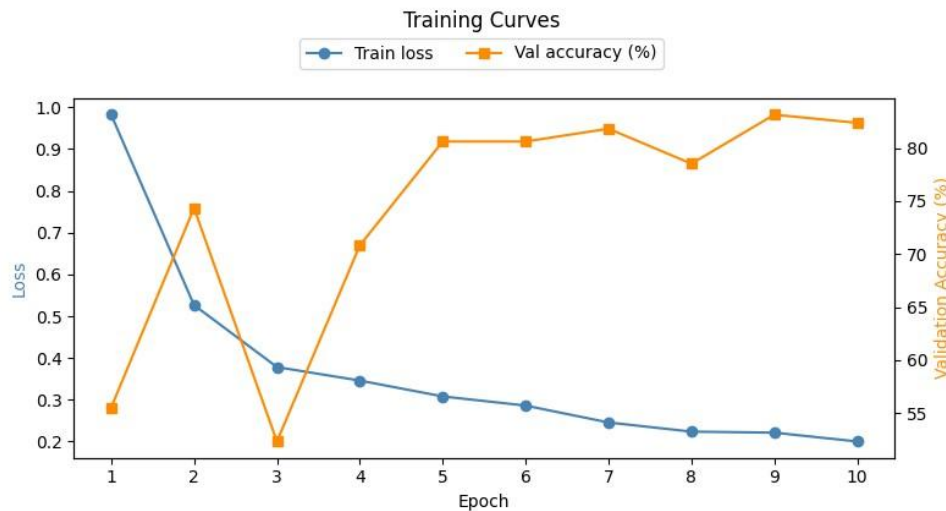
Table 10

Code 3.9. Data augmentation applied to the point cloud before voxelization: random rotation on the Z-axis and Gaussian noise

```
def augment_point_cloud(points):
    """Random rotation on the Z-axis + Gaussian noise."""
    # Rotation around the vertical axis (Z) by a random angle theta =
    random.random() * 2.0 * math.pi
    cos_t, sin_t = math.cos(theta), math.sin(theta)
    rotation_matrix = np.array(
        [[cos_t, -sin_t, 0],
         [sin_t, cos_t, 0],
         [0, 0, 1]],
        dtype=np.float32,
    )
    rotated = (rotation_matrix @ points.T).T
    # Gaussian noise to simulate scan imperfections
    noise = np.random.normal(loc=0.0, scale=0.02, size=rotated.shape)
    return rotated + noise.astype(np.float32)
```

Figure 9

Training curves of ResNet3D-18 over ModelNet10 over 10 epochs. The training loss (blue) decreases monotonically while the validation accuracy (orange) stabilizes at around 82%



3.7 EVALUATION AND ANALYSIS OF RESULTS

Training a model is only half the work—the other half is understanding what it has learned. A single metric of overall accuracy can mask serious problems: a model that gets 83% right on the test set might be getting almost 100% right in some classes and less than 60% in others. In this section, we explore three tools that help diagnose this type of behavior.

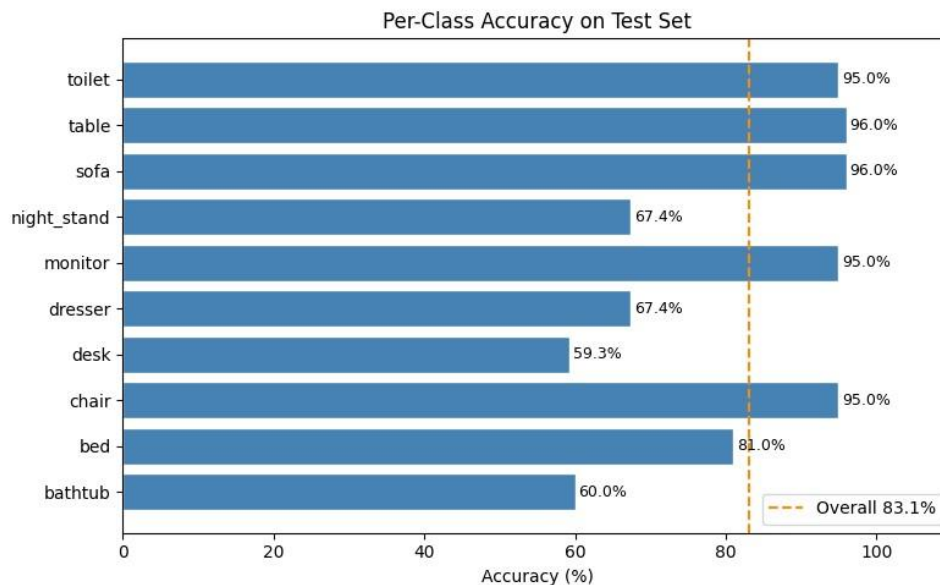
3.7.1 Overall and Class Accuracy

The overall accuracy of our 10-epoch-trained model is 83.1%. That's a good number of starts, but not enough on its own — especially since some classes have far more test samples than others, which means that errors in smaller classes weigh little in the overall average.

Accuracy by class reveals the full spectrum. Figure 10 shows that classes with very different volumetric geometries — *table*, *sofa*, *chair*, *monitor*, and *toilet* — reach an accuracy of around 95%, while *bathtub* (60%), *desk* (59.3%), *dresser*, and *night_stand* (67.4%) are well below the average and are the main responsible for pulling it down.

Figure 10

Accuracy per class in the ModelNet test set10. The dashed line indicates an overall accuracy of 83.1%. Classes with distinct volumetric geometry achieve accuracy close to 95%, while geometrically ambiguous classes are below average



3.7.2 Confusion Matrix

When a class has low accuracy, the next natural question is, "What is it being confused with?" The confusion matrix responds to this. It is a $C \times C$ *table* in which the entry in row i and column j indicates the proportion of samples of true class i that have been classified as j . The main diagonal contains the hits; everything outside the diagonal are mistakes.

Figure 11 shows the normalized matrix of our model. Four patterns of confusion stand out:

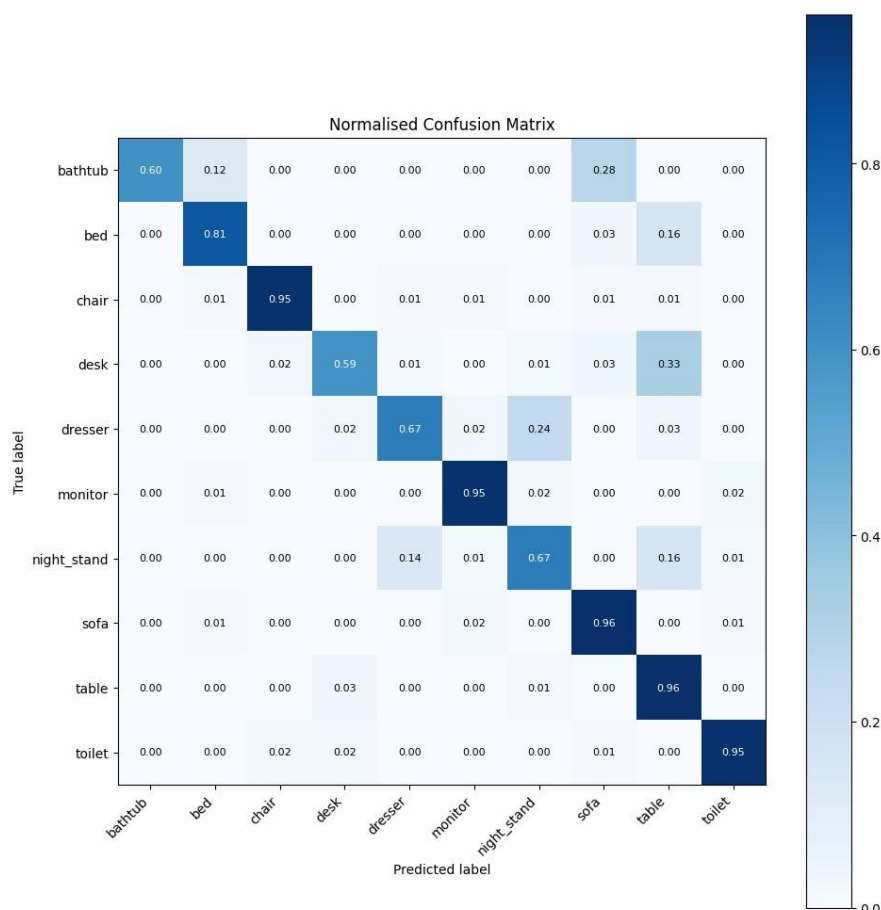
- *Desk* confused with *table* (33%): both are horizontal tops on legs, and the distinction between the two is more functional than geometric.
- *Bathtub* mistaken for *sofa* (28%): Seen as volumes with low walls and upper cavity, bathtubs and sofas have strikingly similar shapes at low resolution.
- *Dresser* confused with *night_stand* (24%), and the reverse (14%): both are vertical rectangular boxes, differing basically in size — and size is precisely the dimension we lose when normalizing each object to the unit cube.
- *Bed* confused with *table* (16%): beds voxelized in 323 essentially become a horizontal plane on supports, geometry close to that of a table.

The network is, in a sense, "right" in seeing geometric similarity—only that these classes were defined by human use, not pure form, and the model only sees form. This pattern also

suggests a concrete direction for improvement: preserving absolute-scale information (rather than normalizing everything to the unit cube) could help separate pairs like *dresser/night_stand*.

Figure 11

Normalized confusion matrix in the test set. Diagonal values indicate correct answers by class; Cells outside the diagonal reveal systematic confusions between geometrically similar classes



3.8 CONSIDERATIONS FOR 3D MODELS

In the previous sections we built a complete 3D classifier: we started from meshes in the OFF format, went through the sampling-normalization-voxelization pipeline, trained an adapted ResNet3D-18 and analyzed its performance in ModelNet10. The path taken is parallel to that of the 2D classification presented in the first half of this chapter, but with a fundamental difference: in 3D, the pre-processing is as important as the architecture of the model.

Voxel representation is didactic and fits naturally into conventional CNNs, but it carries important limitations. The cost of memory grows with the cube of resolution—doubling from 323 to 643 multiplies voxels eightfold—which makes it difficult to capture fine details on modest

hardware. Moreover, most of a voxel grid is empty space: the surface of a 3D object is essentially a 2D structure, and storing it in a dense grid represents an inefficient use of memory.

For the reader who wants to take the next steps, a natural direction is to experiment with ModelNet40, the expanded version with 40 classes. The pipeline we've built here—OFF reading, point sampling, PyTorch integration—continues to serve as the foundation and can be reused directly. What remains regardless of scale is the overall structure of the problem: raw data → representation appropriate to the architecture → training → critical evaluation. These steps are the skeleton of any 3D computer vision project.

4 CONCLUSION

Throughout this chapter you have been introduced to a solid foundation of *modern computer vision pipelines*, ranging from the fast applications of the YOLO ecosystem in 2D to the more rigorous pre-processing models required for 3D classifications. While modern architectures such as YOLO abstract much of the complexity of models to provide efficient inferences on real images and videos, Working with three-dimensional volumes imposes other architectural challenges, with a high computational cost of voxelization and the data losses inherent to spatial normalization.

While useful, these templates are not without error. A rigorous analysis, as presented here in the ModelNet10 confounding matrix, reveals the potential for the model to confuse objects for their pure geometric similarities (such as chairs and tables), and the same can happen with YOLO, misclassifying and detecting objects. This demonstrates that the critical evaluation of what the model has effectively learned is as crucial as its training. The implementations and concepts discussed here therefore serve as a practical guide to the implementation and use of these techniques. With these foundations, the reader will now be able to expand these solutions and apply them to new data sets and creating their own solutions for study or real problems - but they will not do without critical evaluation of their applications.

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PLANT GROWTH-PROMOTING BACTERIA IN THE CONTROL OF *FUSARIUM SP*

BACTÉRIAS PROMOTORAS DE CRESCIMENTO VEGETAL NO CONTROLE DE *FUSARIUM SP*

BACTERIAS PROMOTORAS DEL CRECIMIENTO VEGETAL EN EL CONTROL DE *FUSARIUM SP*



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ABSTRACT

The use of plant growth-promoting bacteria (PGPB) has emerged as a sustainable alternative for agricultural management and control of phytopathogens. This study aimed to evaluate the potential of PGPB in controlling *Fusarium sp.* and promoting plant development. The experiment was conducted in vitro at the Laboratory of Microbial Interactions and Biotechnology (LIMBio/IF Goiano – Campus Ceres), using the bacteria *Bacillus amyloliquefaciens*, *Bacillus subtilis*, and *Priestia aryabhatai*. The antagonism assay was performed by co-inoculation in PDA medium, and the mycelial growth of the fungus was measured to calculate the relative control index. The data were subjected to analysis of variance and Tukey's test ($p < 0.05$). All treatments showed a significant effect in controlling the pathogen, with *Bacillus amyloliquefaciens* standing out, exhibiting the highest antagonism index (69.87%), statistically differing from *Bacillus subtilis* (31.57%) and *Priestia aryabhatai* (15.30%). The results indicate that *B. amyloliquefaciens* has high potential as a biocontrol agent for *Fusarium sp.*, and may contribute to reducing the use of agrochemicals and developing more sustainable agricultural practices.

Keywords: Biocontrol. *Fusarium Sp.* *Bacillus*. Sustainability. Microorganisms.

RESUMO

O uso de bactérias promotoras de crescimento de plantas (BPCP) tem se destacado como alternativa sustentável para o manejo agrícola e controle de fitopatógenos. Este estudo teve como objetivo avaliar o potencial de BPCP no controle de *Fusarium sp.* e na promoção do desenvolvimento vegetal. O experimento foi conduzido in vitro no Laboratório de Interações

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Microbianas e Biotecnologia (LIMBio/IF Goiano – Campus Ceres), utilizando as bactérias *Bacillus amyloliquefaciens*, *Bacillus subtilis* e *Priestia aryabhatai*. O ensaio de antagonismo foi realizado por co-inoculação em meio BDA, e o crescimento micelial do fungo foi mensurado para cálculo do índice relativo de controle. Os dados foram submetidos à análise de variância e teste de Tukey ($p < 0,05$). Todos os tratamentos apresentaram efeito significativo no controle do patógeno, com destaque para *Bacillus amyloliquefaciens*, que apresentou maior índice de antagonismo (69,87%), diferindo estatisticamente de *Bacillus subtilis* (31,57%) e *Priestia aryabhatai* (15,30%). Os resultados indicam que *B. amyloliquefaciens* possui elevado potencial como agente de biocontrole de *Fusarium sp.*, podendo contribuir para a redução do uso de agroquímicos e para o desenvolvimento de práticas agrícolas mais sustentáveis.

Palavras-chave: Biocontrole. *Fusarium Sp.* Bacillus. Sustentabilidade. Microrganismos.

RESUMEN

El uso de bacterias promotoras del crecimiento vegetal (BPCP) se ha destacado como una alternativa sostenible para el manejo agrícola y el control de fitopatógenos. Este estudio tuvo como objetivo evaluar el potencial de las BPCP en el control de *Fusarium sp.* y en la promoción del desarrollo vegetal. El experimento se llevó a cabo *in vitro* en el Laboratorio de Interacciones Microbianas y Biotecnología (LIMBio/IF Goiano – Campus Ceres), utilizando las bacterias *Bacillus amyloliquefaciens*, *Bacillus subtilis* y *Priestia aryabhatai*. El ensayo de antagonismo se realizó mediante coinoculación en medio BDA, y el crecimiento micelial del hongo fue medido para el cálculo del índice relativo de control. Los datos fueron sometidos a análisis de varianza y prueba de Tukey ($p < 0,05$). Todos los tratamientos presentaron un efecto significativo en el control del patógeno, destacándose *Bacillus amyloliquefaciens*, que presentó el mayor índice de antagonismo (69,87%), diferenciándose estadísticamente de *Bacillus subtilis* (31,57%) y *Priestia aryabhatai* (15,30%). Los resultados indican que *B. amyloliquefaciens* posee un alto potencial como agente de biocontrol de *Fusarium sp.*, pudiendo contribuir a la reducción del uso de agroquímicos y al desarrollo de prácticas agrícolas más sostenibles.

Palabras clave: Biocontrol. *Fusarium sp.* Bacillus. Sostenibilidad. Microorganismos.

1 INTRODUCTION

The use of biological inputs based on beneficial soil microorganisms, such as Plant Growth Promoting Bacteria (BPCP), stands out as one of the most promising technologies to achieve the sustainability of agricultural systems. These bacteria can promote significant improvements, from traits linked to shoot and root growth to enzymatic protection against biotic and abiotic stresses (Kaushal; Wani, 2016; Porto et al., 2022).

These innovations are relevant to today's agriculture, as they help to address challenges associated with unsustainable agricultural practices. Among the main problems are the excessive use of agrochemicals, deforestation, monoculture, soil exhaustion, agriculture in inadequate areas, inadequate use of water, waste of resources, and pollution of soil and water, which compromise the health of ecosystems and productive sustainability (Kaushal; Wani, 2016; Porto et al., 2022).

Microorganisms also act on the availability of phosphorus to crops, converting forms of ions into forms that can be assimilated by plants. In addition, they produce enzymes and organic acids in the region near the roots, favoring the dissolution of phosphorus present in the soil in mineralized mineral and organic forms (Porto et al., 2022).

In crop management, different microorganisms act as soil and plant pathogens, causing damage and losses. Thus, control strategies have been widely investigated, with emphasis on more sustainable alternative methods. Among the alternatives, *Bacillus subtilis* has mechanisms of action that influence plant development, with benefits associated with improved nutrition (biological nitrogen fixation and phosphate solubilization) and growth promotion related to phytohormone production (Swarnalakshmi et al., 2020). In a study with passion fruit, the application of *Bacillus subtilis* on leaves demonstrated a preventive and curative effect in the control of the phytopathogen *Fusarium* sp. (Chen, Lee, and Huang, 2021).

Bacillus amyloliquefaciens stands out as an important biocontrol agent, being able to suppress phytopathogens by mechanisms related to fungal cell wall degradation and changes in cell permeability. In addition, contact with the pathogen can induce the production of antifungal compounds, such as lipopeptides, intensifying the antagonist action (Abreu et al., 2022).

Priestia aryabhattai, in turn, acts as a promoter of plant growth and contributes to tolerance to water stress through the production of exopolysaccharides, which help retain water in the soil and induce physiological adaptations in plants, favoring development in conditions of water deficit (Embrapa, 2021). Additionally, the use of bacteria can reduce the need for chemical fertilizers, while also favoring growth and increasing productivity.

Therefore, this work aims to evaluate the potential of plant growth-promoting bacteria in the control of *Fusarium* sp. and in the promotion of plant development, through the *in vitro* analysis of the bacteria *Bacillus subtilis*, *Bacillus amyloliquefaciens* and *Priestia aryabhattai*, in order to compare their efficiency in antagonism to the phytopathogen.

2 MATERIAL AND METHODS

The experiment was conducted at the Laboratory of Microbial Interactions and Biotechnology (LIMBio), located at the Federal Institute of Education, Science and Technology of Goiano (IF Goiano – Ceres Campus), in the municipality of Ceres, Goiás, Brazil (15°21'02"S latitude, 49°35'55"W longitude, and altitude of 564 m). The bacterial strains used were commercial products: *P. aryabhattai* B. *subtilis* B. *amyloliquefaciens* CCT 7986 (BioHidric – 1.0×10^8 colony-forming units (CFU) mL⁻¹, SoluBio, Jataí, Brazil), UFV S1 (Bio Raiz Pro – 1.0×10^8 CFU mL⁻¹, SoluBio, Jataí, Brazil) and CCT 7994 (SoluStrong – 1.0×10^8 CFU mL⁻¹, SoluBio, Jataí, Brazil).

To perform the antagonism assay to the phytopathogenic fungus, the bacterial suspensions were co-inoculated *in vitro* with the phytopathogenic fungus *Fusarium* spp. 5 mm discs of fungal mycelium were inoculated in the center of Petri dishes containing potato-dextrose-agar culture medium (B.D.A) and, at 2 cm equidistant from the disc, 5 µL of bacterial culture were deposited. The control consisted only of the mycelial disc of the fungus deposited in the center of the plate.

The plates were incubated at 28 °C in a B.O.D. incubator, and the experiment was conducted in triplicate. The diameter of the mycelium was measured with the aid of a caliper until the control treatment reached the edge of the plate. The percentage of suppression for each treatment was calculated using the relative index (RI) according to Trivedi et al. (2008).

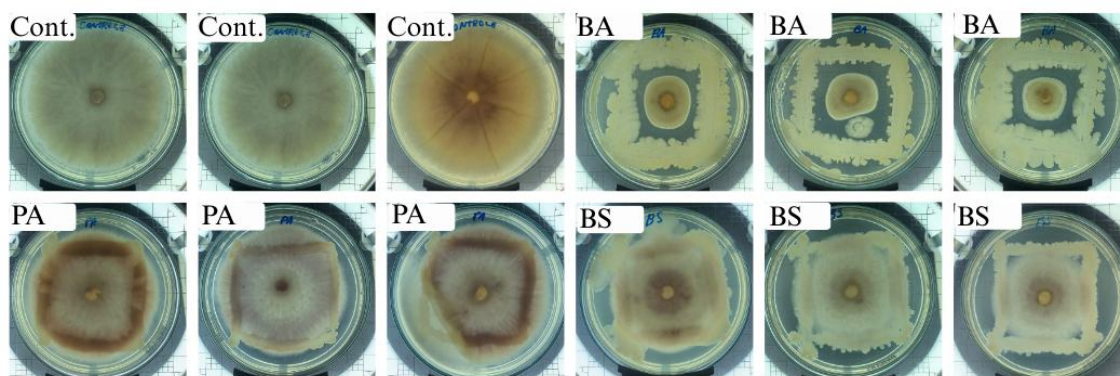
All data collected were initially tested for normality. If the prerequisites were met, the results were submitted to analysis of variance (ANOVA) followed by Tukey's test, using R and RStudio software (R Core Team, 2024). All results were considered significant at $p < 0.05$.

3 RESULTS AND DISCUSSIONS

All three bacteria tested showed a significant antagonistic effect against *Fusarium* sp. (Figure 1).

Figure 1

In vitro bacterial antagonism test to *Fusarium* sp.



Legend: Cont.: Control; BA: *Bacillus amyloliquefaciens*; PA: *Priestia aryabhattai*; BS: *Bacillus subtilis*. Source: Prepared by the authors.

The analysis of variance indicated a significant effect of the treatments on the evaluated variable ($p < 0.0001$), evidencing differences between the means, as shown in Table 1. According to Tukey's test, the treatment with *Bacillus amyloliquefaciens* presented the highest relative control index, with 69.87%, differing statistically from the treatments with *Bacillus subtilis* (31.57%) and *Priestia aryabhattai* (15.30%), which also differed from each other, forming distinct response groups. These results demonstrate that the treatment with *Bacillus amyloliquefaciens* provided significantly superior performance compared to the others when controlling *in vitro* the phytopathogenic fungus *Fusarium* sp.

Table 1

Relative Index (RI) of in vitro bacterial antagonism to Fusarium sp.

Treatments	IR (%)
<i>Bacillus amyloliquefaciens</i>	69.86667
<i>Bacillus subtilis</i>	31.56667
<i>Priestia aryabhattai</i>	15.3 c
F.V	p-value
Treatment	0,001**
CV (%)	26,11

Legend: Different letters in the column differ significantly by Tukey's test. *Significant at the level of 5% by Tukey's test; **Significant at the level of 1% by Tukey's test; ns: Not significant. F.V.: source of variation; C.V. (%): coefficient of variation. Source: Prepared by the authors.

These results corroborate the findings of Elanchezhiyan *et al.* (2018), which obtained a control percentage of 48.3% in the *in vitro* control of *Fusarium oxysporum* f. sp. *Lycopersici* with the FZB 24 strain of *B. amyloliquefaciens*. Similarly, Sundaramoorthy and Balabaskar (2013) reported the efficacy of *B. subtilis* isolates in inhibiting up to 40% the mycelial growth of

F. oxysporum f. sp. *lycopersici* *in vitro*, which is responsible for causing vascular wilt disease in tomato crops.

Species of *Bacillus* sp. are known to secrete peptides with antimicrobial action, such as phengicin, bacillomycin, and bacteriocin (Ramarathnam *et al.*, 2007; Xie *et al.*, 2009).

It was verified by Yi *et al.* (2024) that the ZK-9 strain of *B. Amyloliquefaciens* produces pectinase, protease, cellulase, and amylase, important enzymes involved in the ability of this bacterium to inhibit the growth of phytopathogenic fungi by disrupting the integrity and permeability of the cell membrane, disrupting metabolic pathways, and preventing pathogens from developing. The authors also observed that the bacterium showed high efficacy in field control, reducing ear fusarium by 71.76% and wheat crown rot by 82.14%, both caused by the fungus *Fusarium graminearum*.

Guleria *et al.* (2016) isolated an alkaline protease gene from the SP1 strain of *Bacillus amyloliquefaciens* and evaluated its antagonist activity *in vitro* against *F. oxysporum* using the agar diffusion technique. The authors observed that the enzyme was highly effective, reducing the growth of the pathogen by 35.07%, which highlights the role of the enzymes produced by *B. amyloliquefaciens* in its ability to control phytopathogenic fungi, such as *Fusarium* sp.

4 CONCLUSION

The results demonstrate that the bacteria evaluated had a significant effect on the *in vitro* control of *Fusarium* sp., especially *Bacillus amyloliquefaciens*, which showed the highest efficiency of antagonism. *Bacillus subtilis* showed an intermediate effect, while *Priestia aryabhattai* had a lower performance. Thus, *B. amyloliquefaciens* stands out as a promising alternative for the biocontrol of the pathogen, with potential application in sustainable agricultural systems.

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THE FUTURE OF EMPLOYMENT IN MANAUS, AMAZONAS: LEGAL CHALLENGES IN THE FACE OF ARTIFICIAL INTELLIGENCE AND LABOR AUTOMATION

O FUTURO DO EMPREGO EM MANAUS, AMAZONAS: DESAFIOS JURÍDICOS DIANTE DA INTELIGÊNCIA ARTIFICIAL E DA AUTOMAÇÃO LABORAL

EL FUTURO DEL EMPLEO EN MANAUS, AMAZONAS: DESAFÍOS JURÍDICOS FRENTE A LA INTELIGENCIA ARTIFICIAL Y LA AUTOMATIZACIÓN LABORAL



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ABSTRACT

The advancement of artificial intelligence and automation has driven significant transformations in the world of work, directly impacting productive organization, employability, and labor legal relations. In this context, the present study aims to analyze the future of employment in Manaus, Amazonas, with emphasis on the legal challenges arising from the incorporation of these technologies into the productive environment, particularly within the Industrial Pole of Manaus. The research is characterized as a qualitative literature review, based on recent scientific studies and relevant institutional documents selected according to criteria of timeliness, thematic relevance, and academic rigor. The findings indicate that automation tends to replace repetitive tasks while increasing the demand for higher levels of professional qualification, which may intensify social inequalities if not accompanied by appropriate public policies. Furthermore, the study reveals that Labor Law faces limitations in regulating new forms of work organization mediated by technology, highlighting the need for normative updates. It is concluded that the future of employment in Manaus will depend on the articulation between technological innovation, legal regulation, and public policies, in order to ensure economic development with social inclusion and protection of workers' rights.

Keywords: Automation. Employment. Labor Law. Artificial Intelligence. Manaus.

RESUMO

O avanço da inteligência artificial e da automação tem promovido transformações significativas no mundo do trabalho, impactando diretamente a organização produtiva, a empregabilidade e

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as relações jurídicas laborais. Nesse contexto, o presente estudo tem como objetivo analisar o futuro do emprego em Manaus, Amazonas, com ênfase nos desafios jurídicos decorrentes da incorporação dessas tecnologias no ambiente produtivo, especialmente no âmbito do Polo Industrial. A pesquisa caracteriza-se como uma revisão de literatura, de abordagem qualitativa, fundamentada em estudos científicos recentes e documentos institucionais relevantes, selecionados a partir de critérios de atualidade, pertinência temática e rigor acadêmico. Os resultados indicam que a automação tende a substituir atividades repetitivas, ao mesmo tempo em que exige maior qualificação profissional, podendo ampliar desigualdades sociais se não houver políticas públicas adequadas. Verificou-se, ainda, que o Direito do Trabalho enfrenta limitações para regular as novas formas de organização laboral mediadas por tecnologia, evidenciando a necessidade de atualização normativa. Conclui-se que o futuro do emprego em Manaus dependerá da articulação entre inovação tecnológica, regulação jurídica e políticas públicas, de modo a garantir desenvolvimento econômico com inclusão social e proteção dos direitos dos trabalhadores.

Palavras-chave: Automação. Direito do Trabalho. Emprego. Inteligência Artificial. Manaus.

RESUMEN

El avance de la inteligencia artificial y de la automatización ha promovido transformaciones significativas en el mundo del trabajo, impactando directamente la organización productiva, la empleabilidad y las relaciones jurídicas laborales. En este contexto, el presente estudio tiene como objetivo analizar el futuro del empleo en Manaus, Amazonas, con énfasis en los desafíos jurídicos derivados de la incorporación de estas tecnologías en el entorno produtivo, especialmente en el Polo Industrial. La investigación se caracteriza como una revisión de literatura de enfoque cualitativo, fundamentada en estudios científicos recientes y documentos institucionales relevantes, seleccionados con base en criterios de actualidad, pertinencia temática y rigor académico. Los resultados indican que la automatización tiende a sustituir tareas repetitivas, al mismo tiempo que exige mayor cualificación profesional, pudiendo ampliar las desigualdades sociales si no existen políticas públicas adecuadas. Asimismo, se constató que el Derecho del Trabajo enfrenta limitaciones para regular las nuevas formas de organización laboral mediadas por la tecnología, evidenciando la necesidad de actualización normativa. Se concluye que el futuro del empleo en Manaus dependerá de la articulación entre innovación tecnológica, regulación jurídica y políticas públicas, con el fin de garantizar desarrollo económico con inclusión social y protección de los derechos de los trabajadores.

Palabras clave: Automatización. Derecho del Trabajo. Empleo. Inteligencia Artificial. Manaus.

1 INTRODUCTION

The intensification of the use of artificial intelligence and automated systems has promoted profound transformations in the world of work, directly impacting the way productive activities are organized and executed. This process, associated with the consolidation of industry 4.0, has been changing not only the economic dynamics, but also the legal relationships that structure the bond between workers and employers. In this context, automation ceases to be a merely technological phenomenon and starts to assume a structural character, influencing the generation of jobs, professional qualification and the very configuration of the contemporary labor market. As observed by Perosini (2024), the replacement of repetitive tasks by automated systems shows a significant change in the profile of occupations, requiring new skills and increasing the challenges for labor insertion.

In the Brazilian scenario, such transformations take on even more relevant contours in the face of economic and regional specificities. The adoption of technologies based on artificial intelligence occurs in a heterogeneous way, impacting the various productive sectors and regions of the country in a different way. Lima (2021) highlights that automation tends to affect activities traditionally dependent on labor with greater intensity, which can generate significant effects on employability and income distribution. This context highlights the need to understand the impacts of these changes not only at the national level, but also from regional perspectives that allow the identification of their particularities and specific implications.

In the case of Manaus, Amazonas, the analysis of the future of employment becomes even more relevant due to the centrality of the Industrial Pole in the local economy. Institutional data indicate that the productive structure of the region is strongly linked to the performance of this sector, which makes the incorporation of technologies a determining factor for maintaining competitiveness and job creation. According to SUFRAMA (2026), the Manaus Industrial Pole represents one of the main axes of regional economic development, being directly influenced by technological modernization processes. In this sense, the introduction of automated systems and artificial intelligence in the industrial environment not only redefines production processes, but also directly impacts the local labor market.

From a legal perspective, these transformations highlight the need to review traditional models of labor regulation. Labor Law, historically structured to deal with face-to-face and hierarchically defined relationships, is now facing challenges arising from digitalization and algorithmic management. Barroso (2024) points out that the incorporation of disruptive technologies requires the construction of new regulatory frameworks capable of balancing innovation and protection of fundamental rights, especially with regard to the dignity of the

worker.

Given this scenario, the following research problem emerges: how do artificial intelligence and automation impact the future of employment in Manaus, Amazonas, and what are the main legal challenges arising from these transformations? The investigation is based on the premise that technological advances, although they promote efficiency gains, can also generate social and normative tensions that demand adequate institutional responses. In this sense, the study seeks to understand how changes in the world of work are articulated with the legal system, especially in the context of a strongly industrialized regional economy.

Thus, the general objective of this article is to analyze the impacts of artificial intelligence and automation on the future of employment in Manaus, Amazonas, with emphasis on the legal challenges associated with these transformations. As specific objectives, it is intended to examine the changes in the structure of the labor market, identify the main risks and opportunities arising from automation and discuss the adequacy of existing legal instruments in the face of new labor dynamics. The relevance of the study lies in the need to produce scientific knowledge that contributes to the debate on the future of work, especially in strategic regional contexts, in which technological innovation is articulated with social and economic issues of great complexity.

The relevance of the theme is also justified by the fact that technological transformations are not limited to the economic dimension, reaching social and legal aspects that require in-depth analysis. The incorporation of intelligent systems into the workplace has the potential to alter the way decisions are made, how workers are evaluated, and how subordinate relationships are established. In this sense, Paes (2025) observes that algorithmic management redefines the control mechanisms in the work environment, introducing new forms of supervision that challenge the traditional models of Labor Law.

In addition, the use of algorithms in recruitment, selection, and performance management processes raises concerns related to transparency and fairness. Coimbra Santos (2024) highlights that automated systems can reproduce discriminatory patterns, especially when based on biased historical data. This reality reinforces the need to develop regulatory mechanisms that ensure the protection of workers in the face of automated decisions, avoiding the expansion of inequalities that already exist in the labor market.

Another relevant aspect refers to the reconfiguration of employment power in the face of the adoption of digital technologies. Artur (2025) argues that the use of algorithms in work management shifts the decision-making center of labor relations, creating new dynamics of subordination that do not fully fit into traditional models. This transformation highlights the need

to review classic legal concepts, in order to ensure that labor protection keeps up with technological changes.

In the field of social rights, the literature points out that automation can generate significant impacts on working conditions. Gervasoni (2024) points out that, although technological innovation promotes efficiency, it can also contribute to the precariousness of labor relations, especially in contexts marked by excessive flexibility. This finding reinforces the importance of a legal action that seeks to balance technological development and social protection.

Additionally, the analysis of the local context shows that the adoption of technologies in the Manaus Industrial Pole occurs gradually, being influenced by structural and institutional factors. Rocha (2024) shows that the digital transformation in the region's industrial sector presents important advances, but also challenges related to the qualification of the workforce and the adaptation of companies to new technological requirements. This scenario reinforces the need for public policies aimed at professional training and strengthening the regional productive base.

Thus, it is highlighted that understanding the future of employment in Manaus requires an integrated approach, which considers the interactions between technology, economics and law. Moreira (2025) points out that the absence of specific regulation to deal with the impacts of artificial intelligence on labor relations can generate legal uncertainty, evidencing the need for regulatory updating. In this way, the study is part of a relevant and current field of investigation, contributing to the academic debate and to the construction of solutions that promote the sustainable development of work in the digital age.

2 THEORETICAL FRAMEWORK

The analysis of the future of employment, especially in regional contexts such as Manaus, Amazonas, requires the articulation between technological transformations, productive dynamics and the legal mechanisms that seek to regulate labor relations in constant mutation. In this scenario, artificial intelligence and automation assume a central role, not only as instruments for increasing productivity, but as elements that redefine the very structure of contemporary work. Barroso (2024) argues that the advancement of these technologies imposes relevant regulatory challenges, especially due to the need to balance technological innovation with the protection of fundamental rights, which includes the right to decent work.

Recent literature points out that automation and intelligent systems have been promoting structural changes in the labor market, with direct impacts on employability and productive

organization. According to Perosini (2024), the advance of industry 4.0 intensifies the phenomenon of technological unemployment, as it replaces repetitive and operational activities with automated systems. This transformation is not limited to the elimination of jobs, but also implies the creation of new professional demands, requiring higher levels of qualification and constant adaptation of workers.

In the Brazilian context, such transformations take on specific contours, especially in industrialized regions. Lima (2021) highlights that automation tends to have a more intense impact on traditional productive sectors, significantly changing the occupational structure and expanding the need for public policies aimed at professional requalification. This perspective is particularly relevant for understanding the Amazonian reality, where the economic base is strongly linked to the industrial sector.

In the case of Manaus, the Industrial Pole represents one of the main economic engines in the region, being directly affected by the digitalization and automation processes. Rocha (2024) shows that the introduction of technologies associated with industry 4.0 has promoted gains in efficiency and competitiveness, but also reveals challenges related to the qualification of the local workforce and the adaptation of production structures. This scenario demonstrates that technological advancement, while bringing economic benefits, can also deepen inequalities if there are no adequate inclusion and training policies.

From a legal perspective, these changes impose the need to reinterpret the traditional institutes of Labor Law. Paes (2025) points out that the incorporation of systems based on artificial intelligence changes the forms of control and subordination in the work environment, requiring the construction of new regulatory paradigms. In this sense, the author highlights that the emergence of a Labor Law focused on the digital reality is indispensable to deal with the specificities of relationships mediated by algorithms.

Additionally, the increasing use of technologies in labor management raises concerns related to transparency and fairness. Coimbra Santos (2024) argues that algorithmic systems can reproduce discriminatory patterns, especially when operating on the basis of biased historical data. This problem reinforces the need for legal mechanisms that ensure control, auditability, and accountability in the use of these technologies, avoiding the perpetuation of inequalities in the labor market.

The reconfiguration of employment power is also a relevant aspect in this debate. Artur (2025) observes that the use of algorithms in labor management shifts the decision-making center of labor relations, creating new forms of subordination that do not fully fit into traditional models. This displacement requires an in-depth reflection on the limits of the employer's power

and on the need to ensure effective protection for workers in highly technologized environments.

On the other hand, the incorporation of technologies in the world of work does not occur without social costs. Gervasoni (2024) points out that, although technological innovation can generate efficiency gains, it can also contribute to the precariousness of working conditions and the weakening of social rights. This aspect shows that the discussion about the future of employment cannot be restricted to the economic dimension, but must also consider the social and legal impacts of these transformations.

In this context, understanding the future of employment in Manaus requires an integrated analysis between technological advances, the local productive structure and the legal instruments available to regulate these changes. The official indicators of SUFRAMA (2026) demonstrate the relevance of the Industrial Pole for the regional economy, which reinforces the importance of understanding how automation and artificial intelligence can impact job creation and work dynamics in the region.

The intensification of the use of digital technologies in the productive environment has caused not only quantitative changes in the labor market, but also qualitative transformations in the forms of organization, control and execution of work activities. In this sense, Moreira (2025) highlights that the replacement of human labor by automated systems directly challenges the normative structure of the Consolidation of Labor Laws, requiring the updating of its provisions to deal with new forms of labor provision. Such a scenario shows that Labor Law, historically built on the centrality of the traditional employment relationship, finds it difficult to encompass emerging realities mediated by artificial intelligence.

From this perspective, it is observed that automation does not only eliminate jobs, but redefines fundamental legal categories, such as subordination, working hours, and employer responsibility. Paes (2025) points out that algorithmic management introduces a diffuse form of control, in which decisions are made by automated systems, often without transparency or the possibility of contestation by the worker. This new configuration challenges the very notion of directive power, requiring the construction of legal instruments capable of ensuring balance in labor relations.

In this context, the problem of algorithmic opacity stands out. Artur (2025) argues that the use of automated systems in work management makes it difficult to identify the criteria used in decisions, which can compromise workers' fundamental rights. The absence of transparency not only limits the exercise of adversarial proceedings, but also makes it difficult to hold accountable in cases of unfair or discriminatory decisions, which reinforces the need for specific regulatory mechanisms.

The discussion about algorithmic discrimination is also part of this scenario. Coimbra Santos (2024) shows that algorithms can reproduce discriminatory patterns that already exist in society, increasing gender, race, and class inequalities in access to employment. This finding reveals that technological neutrality is a myth, and it is essential that the legal system establishes clear parameters for the ethical and responsible use of these tools in the workplace.

At the same time, the literature points out that the impacts of automation are not uniform among the different economic sectors. Perosini (2024) observes that sectors that are more intensive in repetitive activities tend to be more quickly replaced by automated systems, while functions that require creativity, complex decision-making, and human interaction have greater resilience. In the context of Manaus, this differentiation is particularly relevant, considering the diversity of activities developed in the Industrial Pole.

The local reality reinforces the need for contextualized analysis. Rocha (2024) demonstrates that the adoption of industry 4.0 technologies in the Manaus Industrial Pole occurs gradually, marked by challenges related to technological infrastructure and the qualification of the workforce. This transition shows that the impact of automation depends not only on technological advancement, but also on the structural and institutional conditions of the region.

In addition, the economic dimension of these transformations cannot be dissociated from the legal analysis. Lima (2021) points out that automation can generate productivity gains and economic growth, but it also tends to widen inequalities, especially when not accompanied by adequate public policies. This duality reinforces the need for state action to promote inclusion and reduce the negative effects of technological unemployment.

From the perspective of social rights, Gervasoni (2024) points out that the incorporation of technologies in the world of work can result in precariousness, especially when there are no adequate protection mechanisms. The flexibilization of labor relations, associated with the intensive use of technology, can weaken historically conquered guarantees, requiring a more active role of the Law in the defense of the dignity of the worker.

The analysis of economic indicators reinforces the centrality of the Manaus Industrial Pole in the generation of jobs and income in the region. SUFRAMA data (2026) show that the performance of the industrial sector directly impacts the local labor market, which makes it even more relevant to understand the effects of automation on this structure. In this sense, the future of employment in Manaus depends not only on technological evolution, but also on the ability of legal institutions and public policies to adapt to the new demands of the contemporary world of work.

The consolidation of artificial intelligence and automation in the production environment also raises reflections on the need to redefine the very foundations of Labor Law. In this sense, Barroso (2024) points out that digital transformation does not only represent a technological change, but a structural change in the forms of social and economic organization, requiring institutional responses that preserve the centrality of the dignity of the human person. Such a perspective reinforces that the regulation of labor, in the face of this new scenario, must be guided by constitutional principles capable of ensuring a balance between innovation and social protection.

From this approach, it is evident that the future of employment cannot be understood in isolation, but as part of a broader system of economic and social relations. Lima (2021) highlights that the effects of automation on the labor market tend to intensify over time, especially in developing economies, where the technological transition can occur more abruptly. This process requires the formulation of public policies aimed not only at generating jobs, but also at adapting the workforce to new technological requirements.

In the legal field, this transformation imposes challenges related to the effectiveness of existing rules. Moreira (2025) observes that labor legislation, by being based on traditional employment models, presents limitations to regulate new forms of work mediated by technology. The absence of specific devices to deal with automation and artificial intelligence can generate regulatory gaps, making it difficult to protect workers in highly digitized contexts.

In addition, the reconfiguration of labor relations also impacts the very notion of employment relationship. Paes (2025) points out that technological mediation can fragment the relationship between worker and employer, creating situations in which the identification of the person responsible for decisions becomes more complex. This fragmentation challenges classic concepts of Labor Law and requires the construction of new parameters for defining responsibilities and guarantees.

Another relevant aspect refers to the need for transparency and governance in the use of technologies in the workplace. Artur (2025) emphasizes that algorithmic management must be accompanied by mechanisms that allow the understanding of the criteria used in decisions, guaranteeing the worker the right to contest any injustices. This requirement is directly related to the protection of fundamental rights, especially with regard to equality and non-discrimination.

In this context, the problem of algorithmic discrimination takes center stage. Coimbra Santos (2024) shows that the use of automated systems can reproduce existing discriminatory patterns, increasing inequalities in access to employment and working conditions. This finding reinforces the need for specific regulation that establishes limits and responsibilities in the use

of these technologies, ensuring that innovation does not translate into social exclusion.

From a socioeconomic perspective, the impacts of automation are also reflected in working conditions and income distribution. Gervasoni (2024) argues that the incorporation of technologies can generate precariousness, especially when accompanied by excessive flexibility in labor relations. This reality shows that technological advances, although they promote efficiency, can deepen inequalities if there are no adequate mechanisms for social protection.

In the regional context, these transformations take on their own characteristics. Rocha (2024) demonstrates that the Manaus Industrial Pole faces specific challenges related to the implementation of advanced technologies, including structural limitations and the need for labor qualification. This reality reinforces the importance of public policies aimed at regional development, capable of integrating technological innovation with social inclusion.

In turn, Perosini (2024) highlights that the transition to industry 4.0 requires not only investments in technology, but also in education and professional training, in order to avoid the expansion of structural unemployment. This perspective dialogues directly with the reality of Manaus, where dependence on the industrial sector makes the impact of technological transformations on employment even more sensitive.

The data presented by SUFRAMA (2026) show the economic relevance of the Manaus Industrial Pole, reinforcing that any change in its production structure has a direct impact on the local labor market. In this sense, the future of employment in the region depends on the ability to articulate technological innovation, legal regulation, and public policies, in order to ensure that the advances provided by artificial intelligence and automation are accompanied by social protection and the promotion of worker dignity.

3 METHODOLOGY

The present study is characterized as a theoretical research, with a qualitative approach, developed through a literature review. Such a methodological choice is justified by the need to understand, systematize and critically analyze the recent scientific production on the impacts of artificial intelligence and automation on the labor market, with emphasis on the legal challenges and specificities of the context of Manaus, Amazonas. The literature review enables the construction of an analytical panorama based on already consolidated studies, allowing the identification of convergences, gaps and trends in the field investigated.

The research design was structured based on the previous definition of the theme, the research problem and the objectives of the study, guiding the careful selection of sources. The

search for materials took place in databases recognized in the academic environment, prioritizing scientific articles published in relevant journals, as well as institutional documents of recognized credibility. Only recent studies, published in recent years, were considered in order to ensure the timeliness and relevance of the discussions presented.

As inclusion criteria, works were selected that directly addressed the relationship between artificial intelligence, automation, the labor market and Law, with an emphasis on contemporary analyses of labor transformations and their legal developments. Studies that presented relevant contributions to the understanding of the Brazilian context and, especially, the reality of the Manaus Industrial Pole were also included. Materials that did not present scientific rigor, lack of defined authorship, methodological inconsistencies, or disconnection with the object of the research were excluded.

The process of selecting sources involved initial exploratory reading, followed by a more in-depth analysis of the texts considered relevant. Subsequently, the analytical and interpretative reading was carried out, with the objective of extracting concepts, theoretical categories and empirical evidence that would contribute to the construction of the theoretical framework. This procedure allowed the content to be organized in a logical and articulated way, ensuring internal coherence to the study.

Data analysis was conducted qualitatively, using the content analysis technique, with emphasis on the identification of patterns, thematic recurrences, and divergences among the authors. It sought to understand how different theoretical perspectives address the impacts of artificial intelligence and automation on work, as well as the legal challenges arising from these transformations. From this analysis, it was possible to structure interpretative categories that guided the discussion of the results.

With regard to methodological limitations, it is noteworthy that the literature review depends on the availability and quality of the selected sources, and there may be restrictions related to access to certain studies or the scarcity of specific research on the regional approach adopted. In addition, as it is a qualitative approach, the results are subject to the interpretation of the researcher, even if they are based on scientific evidence.

Despite these limitations, the methodology adopted is adequate to the objectives of the study, as it allows an in-depth and critical analysis of the theme, contributing to the understanding of the legal challenges associated with the transformations of work in the context of artificial intelligence and automation, especially in the scenario of Manaus, Amazonas.

The systematization of the sources used throughout the research is essential to ensure methodological transparency, traceability of information and coherence in the construction of

the theoretical framework. Table I below presents, in an organized way, the main works that supported the study, allowing us to visualize the profile of the selected scientific and institutional productions, as well as their adequacy to the investigated theme.

Table 1

Synthesis of the sources used in the research

Lead author / Institution	Document Title	Font type	Year
Artur	Algorithms, work and normative spaces: rebalancing employment power?	Scientific article	2025
Barroso	Artificial intelligence: promises, risks and regulation. Something new under the sun	Scientific article	2024
Coimbra Santos	Algorithmic discrimination in labor relations and human rights	Scientific article	2024
Gervasoni	The hidden costs of technology and the protection of the social right to work	Scientific article	2024
Lima	Exploring the future impact of automation in Brazil	Scientific article	2021
Moreira	The impacts of automation and artificial intelligence on employment relations in the light of the CLT	Scientific article	2025
Paes	Artificial intelligence, human labor and labor law: the challenges and meanings of regulation	Scientific article	2025
Perosini	The impact of industry 4.0 on the labor market and technological unemployment	Scientific article	2024
Rock	Industry 4.0 in the Manaus Industrial Pole: a study on digital transformation in the electronics sector	Academic annals	2024
SUFRAMA	Indicators of the Manaus Industrial Complex, December 2025	Official document	2026

Source: Authors'.

The analysis of the table shows the predominance of recent scientific articles, which reinforces the current and qualified nature of the research. The presence of a relevant institutional source is also observed, which contributes to the empirical contextualization of the Manaus scenario.

The selected productions present a strong thematic convergence around artificial intelligence, automation and their impacts on work, while offering different perspectives, legal, economic and technological, allowing a consistent interdisciplinary approach aligned with the objective of the study.

4 RESULTS AND DISCUSSIONS

The analysis of the selected studies shows that the incorporation of artificial intelligence

and automation in the world of work is not limited to a technological phenomenon, but configures a structural transformation with direct implications on the productive organization and on Labor Law. The results point to convergence among the authors regarding the idea that automation promotes efficiency and productivity gains, while profoundly changing the dynamics of employment. In this sense, Perosini (2024) highlights that the replacement of repetitive tasks by automated systems redefines the role of the worker, requiring new skills and expanding the need for professional qualification.

At the same time, it is observed that this transformation does not occur in a homogeneous way, being conditioned by economic, structural and regional factors. In the context of Manaus, the data analyzed indicate that the Industrial Pole plays a central role in the absorption of labor, which makes its modernization processes particularly relevant for the future of employment in the region. Rocha (2024) shows that the adoption of technologies associated with industry 4.0 has occurred gradually, revealing advances in production efficiency, but also challenges related to the training of the local workforce and the adaptation of industrial structures.

The discussion of the results also reveals that automation directly impacts the occupational structure, promoting both the elimination of certain jobs and the creation of new functions. Lima (2021) observes that this process tends to intensify inequalities, especially in contexts in which there are no effective public policies for professional retraining. This finding reinforces the need for articulation between technological development and inclusion policies, in order to prevent the benefits of innovation from being concentrated in specific groups.

From a legal perspective, the findings indicate that the traditional model of labor regulation faces significant limitations in the face of new forms of labor organization. Moreira (2025) points out that the Consolidation of Labor Laws, although still relevant, presents difficulties in encompassing relationships mediated by digital technologies, especially with regard to the definition of employment relationship and accountability in automated contexts. This normative gap highlights the need to update legal instruments to ensure effective protection for workers.

Another relevant point identified in the studies refers to the transformation of forms of control in the work environment. Paes (2025) argues that algorithmic management introduces continuous and automated supervision mechanisms, which can intensify control over the worker without the same transparency as traditional models. This change alters the very nature of subordination, requiring new theoretical and normative approaches to understand contemporary labor relations.

In addition, the analysis shows that the use of algorithms in work management raises

concerns related to transparency and fairness. Coimbra Santos (2024) highlights that automated systems can reproduce discriminatory patterns, which reinforces the need for control and regulation mechanisms that ensure justice and equality in access to employment. This problem becomes even more relevant in contexts of automated selection, in which decisions can be made without direct human intervention.

On the other hand, the results also point out that technology should not be understood only as a risk factor, but also as an opportunity for positive transformation. Barroso (2024) argues that artificial intelligence can contribute to economic development and innovation, as long as it is accompanied by appropriate regulatory frameworks. This view reinforces the need for a balance between stimulating innovation and protecting fundamental rights, especially in the field of labor.

In this scenario, the reconfiguration of employment power emerges as one of the main consequences of the adoption of digital technologies. Artur (2025) observes that the use of algorithms displaces the decision-making center of labor relations, creating new forms of subordination that challenge traditional models. This change requires the construction of legal mechanisms capable of ensuring transparency and balance in labor relations, avoiding the expansion of asymmetries between employers and workers.

The social impacts of these transformations are also evident. Gervasoni (2024) points out that the incorporation of technologies can result in precarious working conditions, especially when associated with the flexibility of labor relations. This finding shows that technological advances, although they bring economic benefits, can generate negative externalities that need to be considered in the regulation process.

The analysis of institutional data reinforces the relevance of the regional context for understanding the results. The SUFRAMA indicators (2026) demonstrate the importance of the Manaus Industrial Pole in the generation of jobs, showing that any transformation in its productive structure has direct impacts on the local labor market. In this sense, the results point out that the future of employment in Manaus is directly conditioned by the way automation and artificial intelligence will be incorporated into the productive dynamics of the region, requiring integrated responses between technology, law and public policies.

The continuity of the analysis shows that the effects of automation and artificial intelligence are not restricted to the productive plane, reaching structural dimensions of the labor legal system itself. In this sense, Moreira (2025) argues that the progressive replacement of the human workforce by automated systems tends to strain the protective logic of labor legislation, especially with regard to the maintenance of jobs and the guarantee of minimum

rights. Such a scenario reveals that legal regulation, if maintained in traditional ways, may become insufficient to respond to the new forms of work organization.

The discussion of the results also allows us to identify that algorithmic management represents one of the main ruptures in the classic model of subordination. Paes (2025) highlights that the control exercised by automated systems redefines the relationship between employer and employee, to the extent that decisions are made by technological structures that operate continuously and often invisibly. This configuration expands the reach of the directive power, while making it difficult to oversee, requiring more sophisticated legal instruments to ensure balance in labor relations.

In this context, the opacity of artificial intelligence systems emerges as one of the main challenges identified in the literature. Artur (2025) argues that the absence of transparency in the criteria used by algorithms compromises the worker's ability to understand and contest decisions that directly affect their professional life. This limitation impacts not only the right to be heard, but also the effectiveness of labor guarantees, making it necessary to build algorithmic governance mechanisms.

The analysis also highlights the centrality of the issue of algorithmic discrimination in the contemporary debate. Coimbra Santos (2024) points out that automated systems can reproduce historical inequalities present in the data used for their training, which results in discriminatory practices in recruitment, performance evaluation, and career progression. This phenomenon reinforces the need for specific regulation, aimed at preventing biases and promoting equity in the workplace.

From an economic perspective, the results indicate that automation can generate ambivalent effects on the labor market. Lima (2021) observes that, although there is potential for increased productivity and economic growth, there is also a risk of increasing structural unemployment, especially in sectors that are more vulnerable to technological substitution. This duality reinforces the importance of public policies that promote the adaptation of the workforce, reducing the negative impacts of the technological transition.

In the specific case of Manaus, the data analyzed reveal that the impact of automation is directly related to the local production structure. Rocha (2024) shows that the modernization process of the Industrial Pole occurs gradually, being influenced by factors such as technological infrastructure and availability of qualified labor. This reality shows that the adoption of advanced technologies depends on structural conditions that are not always fully consolidated in the region.

In addition, the analysis of institutional indicators reinforces the economic relevance of

the Industrial Pole for the local labor market. SUFRAMA data (2026) indicate that job creation in the region is strongly linked to the performance of the industrial sector, which makes any automation process particularly sensitive. In this sense, the introduction of technologies must be accompanied by strategies that ensure the maintenance of adequate levels of employment and income.

On the other hand, the results also indicate that technological innovation can represent an opportunity for positive transformation, as long as it is properly regulated. Barroso (2024) points out that artificial intelligence has the potential to boost economic development and promote social advances, as long as it is accompanied by regulatory frameworks that ensure the protection of fundamental rights. This perspective reinforces the need for a balance between encouraging innovation and preserving labor guarantees.

The social dimension of these transformations is also manifested in the possible precariousness of working conditions. Gervasoni (2024) highlights that the flexibilization of labor relations, associated with the intensive use of technology, can weaken the social protection of workers. This process shows that technological modernization, if not accompanied by adequate policies, can result in social setbacks, expanding existing inequalities.

The analysis of the results allows us to identify that the reconfiguration of labor relations requires an interdisciplinary approach, which integrates legal, economic and technological aspects. Perosini (2024) reinforces that the transition to industry 4.0 requires not only investments in technology, but also in education and professional training, in order to ensure that workers can adapt to new market demands. Thus, the findings indicate that the future of employment in Manaus will depend on the ability to articulate innovation, legal regulation and public policies aimed at social inclusion.

The final stage of the analysis allows us to advance in the integrated interpretation of the findings, showing that the impacts of artificial intelligence and automation on work cannot be understood in isolation, but rather as part of a broader process of reconfiguration of economic and social relations. In this sense, Barroso (2024) highlights that digital transformation imposes the need to review institutional frameworks, especially with regard to the protection of fundamental rights in contexts of high technological complexity. This perspective reinforces that legal regulation must follow technological evolution, avoiding gaps that may compromise the dignity of the worker.

The joint analysis of the sources also shows that the replacement of human labor by automated systems tends to generate differentiated impacts between sectors and regions. Lima (2021) points out that economies with a strong industrial base, such as Manaus, may face more

intense challenges in the technological transition process, especially due to the concentration of activities susceptible to automation. This finding reinforces the need for specific strategies for regional contexts, considering their productive and social particularities.

From the normative point of view, the results indicate that labor legislation faces a scenario of increasing complexity. Moreira (2025) observes that the absence of specific regulation for the use of artificial intelligence in the workplace can generate legal uncertainty, both for workers and employers. This gap highlights the need to update the legal system, with the creation of rules capable of disciplining the use of emerging technologies in labor relations.

The discussion also reveals that algorithmic management significantly modifies the power structure in the workplace. Paes (2025) argues that the control exercised by automated systems expands the reach of employment power, while reducing the visibility of decisions, making it difficult to contest them. This scenario requires the construction of mechanisms that ensure transparency and accountability, in order to preserve balance in labor relations.

In addition, the analysis shows that the use of algorithms can intensify existing inequalities. Coimbra Santos (2024) points out that the reproduction of biases in automated systems can compromise equitable access to employment, making it essential to implement regulatory measures that ensure justice and equality. This problem demonstrates that technology, far from being neutral, reflects and can amplify preexisting social structures.

In the field of labor relations, the reconfiguration of directive power is also presented as a central element. Artur (2025) points out that the adoption of algorithmic systems redefines the way work is organized and supervised, creating new dynamics of subordination. This transformation requires a review of the traditional concepts of Labor Law, in order to ensure that legal protection keeps up with technological changes.

The social dimension of the results also deserves to be highlighted. Gervasoni (2024) argues that the incorporation of technologies can lead to the precariousness of working conditions, especially when associated with the flexibilization of labor relations. This reality shows that technological advances, although they promote efficiency, can generate adverse effects if there are no adequate public policies to mitigate their impacts.

In the regional context, the analysis confirms the centrality of the Manaus Industrial Pole in the dynamics of employment. Rocha (2024) demonstrates that the technological modernization of the industrial sector is an ongoing process, marked by advances and challenges, especially with regard to the qualification of the workforce. This scenario reinforces the importance of investments in education and training, as a way to ensure the adaptation of workers to the new demands of the market.

Additionally, SUFRAMA data (2026) show that the performance of the Industrial Pole is directly related to the generation of jobs in the region, which makes automation a critical factor for the future of work in Manaus. In this sense, the introduction of technologies must be accompanied by strategies that ensure the economic and social sustainability of the local production model.

The results indicate that the transition to a productive model based on artificial intelligence and automation requires an integrated approach, which articulates technological innovation, legal regulation and public policies. Perosini (2024) highlights that adapting to industry 4.0 depends not only on investments in technology, but also on the ability to prepare the workforce for new challenges. Thus, the discussion shows that the future of employment in Manaus will not be determined exclusively by technological advancement, but by the way society, the State and legal institutions will respond to this transformation process.

The systematic organization of the authors used in the research allows us to visualize in a synthetic way the main theoretical and methodological approaches and results found in the literature analyzed. Table 2 below presents a structured synthesis of the contributions of the selected studies, facilitating the understanding of the convergences and specificities of each approach in the context of artificial intelligence, automation, and their impacts on work.

Table 2

Synthesis of the studies used in the research

Authors	Objective	Method	Main results
Artur	Analyze the impact of algorithms on employment power and labor relations	Theoretical and normative analysis	Identifies reconfiguration of employment power and need for algorithmic transparency
Barroso	Discuss the risks and potentialities of artificial intelligence from a legal perspective	Theoretical-legal essay	It points to the need for regulation that balances innovation and fundamental rights
Coimbra Santos	Investigate algorithmic discrimination in labor relations	Qualitative analysis of theoretical basis	Evidence of reproduction of inequalities by automated systems
Gervasoni	Assessing the social impacts of technology on the right to work	Literature review	Highlights Precariousness and Hidden Social Costs of Automation
Lima	Examine the future impacts of automation on the Brazilian labor market	Empirical analysis and economic projections	It indicates increased inequality and the need for professional retraining
Moreira	Analyze the effects of automation on employment relations in the light of the CLT	Legal and doctrinal study	It points out normative gaps and the need for legislative updating
Paes	Discuss the challenges of artificial intelligence for Labor Law	Theoretical-legal analysis	Highlights changes in subordination and work management
Perosini	Investigating the impacts of industry 4.0 on employment and technological unemployment	Literature review	Identifies task substitution and requirement for new skills

Authors	Objective	Method	Main results
Rock	Analyze the digital transformation in the Manaus Industrial Pole	Case Study	Demonstrates technological advances and local qualification challenges

Source: Authors'.

The analysis of the table shows a strong convergence among the authors regarding the structural impacts of artificial intelligence and automation on the labor market, especially with regard to the reconfiguration of labor relations and the resulting legal challenges.

The predominance of qualitative and theoretical-normative approaches is observed, which reinforces the interpretative character of the theme, combined with the presence of empirical and institutional studies that contribute to the contextualization of the Brazilian and Amazonian reality.

In general, the results indicate that, although technology promotes efficiency and innovation gains, it also imposes significant risks, such as technological unemployment, job insecurity, and widening inequalities, which highlights the need for integrated responses between law, public policies, and technological development.

5 CONCLUSION

The present study allowed us to understand that the future of employment in Manaus, Amazonas, is directly conditioned by the way artificial intelligence and automation have been incorporated into production processes, especially in the scope of the Industrial Pole. The analysis showed that such technologies promote structural transformations in the labor market, redefining functions, professional requirements and forms of labor organization, which imposes significant challenges to contemporary Labor Law.

The results obtained showed that automation, while enhancing efficiency and competitiveness gains, also tends to reduce jobs in repetitive activities, increasing the need for professional qualification and adaptation of the workforce. In this sense, it was found that the transition to a technology-based production model requires not only investments in innovation, but also public policies aimed at the training and requalification of workers, in order to avoid the deepening of social inequalities.

In the legal field, it was found that labor legislation faces limitations to keep up with the new dynamics imposed by digitalization and algorithmic management. The emergence of forms of automated control and the difficulty of fitting these relationships into traditional models highlight the need for regulatory updating, with the construction of instruments capable of guaranteeing effective protection to workers without compromising technological development.

In addition, the research showed that the use of systems based on artificial intelligence can generate risks related to transparency, accountability, and equity in labor relations. The possibility of automated decisions directly influencing the professional lives of workers reinforces the importance of mechanisms that ensure control, auditability, and respect for fundamental rights, especially in contexts marked by power asymmetries.

In the specific context of Manaus, it was observed that the economic dependence of the Industrial Pole makes the region particularly sensitive to technological transformations. Productive modernization, although necessary to maintain competitiveness, must be accompanied by strategies that ensure social inclusion and the sustainability of employment, avoiding negative impacts on the local working population.

In view of this scenario, it is concluded that the future of employment in the region will not be determined exclusively by technological advances, but by the ability to articulate innovation, legal regulation and public policies. It is essential that the State, institutions and the productive sector act in an integrated manner, promoting an environment that favors technological development without compromising the dignity of the worker.

It is noteworthy that the study contributes to the academic debate by highlighting the need for an interdisciplinary approach in the analysis of work transformations, integrating legal, economic and social perspectives. As a limitation, the dependence on secondary sources is recognized, which indicates the importance of future empirical research that deepens the understanding of the impacts of artificial intelligence in the Amazonian context, expanding knowledge about the challenges and opportunities that present themselves for the contemporary world of work.

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It is also worth noting the tribute to the city of Manaus, whose historical trajectory and economic importance inspire reflections on the future of work and contemporary challenges. Finally, we thank family and friends for their constant support throughout the entire journey of writing this article.

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THE ROLE OF HIGH-FIDELITY CLINICAL SIMULATION IN HEALTH EDUCATION

O PAPEL DA SIMULAÇÃO CLÍNICA DE ALTA FIDELIDADE NA EDUCAÇÃO EM SAÚDE

EL PAPEL DE LA SIMULACIÓN CLÍNICA DE ALTA FIDELIDAD EN LA EDUCACIÓN EN SALUD



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ABSTRACT

Health education is one of the most compelling challenges for the current 21st-century generation, enriched by digital means and highly technological. Educating for health proves to be a complex process that requires pedagogical strategies that promote the construction of new knowledge. Understanding the complex phenomenon involving health education and the environments that construct new knowledge allows for an exhaustive reflection on the nature of educational processes and simultaneously constitutes an opportunity for knowledge construction mediated by specialists in active cooperation with the student. From this perspective, high-fidelity clinical simulation stands out as a pedagogical and metacognitive strategy for the development of new fundamental knowledge and skills. Thus, high-fidelity clinical simulation in health education exerts a pedagogical and innovative action by allowing the participation and cooperation of the educational community as a central figure in the entire educational process.

Keywords: Health Education. High-Fidelity Clinical Simulation. Innovation. Health.

RESUMO

A educação em saúde é um dos desafios mais relevantes para a geração atual do século XXI, enriquecida por meios digitais e altamente tecnológicos. Educar para a saúde revela-se um processo complexo que exige estratégias pedagógicas capazes de promover a construção de novos conhecimentos. Compreender o fenômeno complexo que envolve a educação em saúde e os ambientes de construção de novos saberes permite uma reflexão aprofundada sobre a natureza dos processos educativos e, simultaneamente, constitui uma oportunidade de construção do conhecimento mediada por especialistas em cooperação ativa com o estudante. Nessa perspectiva, a simulação clínica de alta fidelidade destaca-se

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como uma estratégia pedagógica e metacognitiva para o desenvolvimento de novos conhecimentos e habilidades fundamentais. Assim, a simulação clínica de alta fidelidade na educação em saúde exerce uma ação pedagógica e inovadora ao permitir a participação e a cooperação da comunidade educacional como figura central em todo o processo educativo.

Palavras-chave: Educação em Saúde. Simulação Clínica de Alta Fidelidade. Inovação. Saúde.

RESUMEN

La educación en salud es uno de los desafíos más relevantes para la generación actual del siglo XXI, enriquecida por medios digitales y altamente tecnológicos. Educar para la salud se revela como un proceso complejo que exige estrategias pedagógicas capaces de promover la construcción de nuevos conocimientos. Comprender el complejo fenómeno que involucra la educación en salud y los entornos de construcción de nuevos saberes permite una reflexión exhaustiva sobre la naturaleza de los procesos educativos y, al mismo tiempo, constituye una oportunidad para la construcción del conocimiento mediada por especialistas en cooperación activa con el estudiante. Desde esta perspectiva, la simulación clínica de alta fidelidad se destaca como una estrategia pedagógica y metacognitiva para el desarrollo de nuevos conocimientos y habilidades fundamentales. Así, la simulación clínica de alta fidelidad en la educación en salud ejerce una acción pedagógica e innovadora al permitir la participación y cooperación de la comunidad educativa como figura central en todo el proceso educativo.

Palabras clave: Educación en Salud. Simulación Clínica de Alta Fidelidad. Innovación. Salud.

1 INTRODUCTION

Health education plays a fundamental role in society in addressing human needs. The vision of educating and promoting health seeks professionalism, critical thinking, creativity, reflection, and a holistic approach, capable of responding to the challenges of a more global, demanding, and infodemic-ridden community.

High-fidelity clinical simulation (HFCS) has proven to be a challenge for all participants, in the pursuit of constructive, interactive, and pedagogical synergies in the construction of new knowledge. Higher education, according to the legal framework, aims for high qualification and scientific production as pillars of knowledge construction, and institutions create conditions for educational, scientific, and technological dissemination (Law nº. 62/2007, 2007). Currently, the continuous transformation of the educational society and the need to provide adequate resources "makes the State the educator of the 'citizen' and the school its privileged instrument" (Formosinho & Machado, 2013, p. 28).

Currently, the transmissive culture of content and the current postmodernity of the 21st century in education still face challenges inherent to a culture that is expected to be critical, reflective, and convergent with the construction of current knowledge available to the community it serves. HFCS, as a pedagogical strategy, seeks, on the one hand, to connect learning experiences that guarantee the student develops competencies as a health educator and ensure this experience without exposing users (individual/family and community) to avoidable risks during the educational process; that is, to develop experiential learning that brings students and teachers closer to real-world practice contexts in a safe environment.

The mission of Higher Education aims at high-level qualification, production, dissemination of interdisciplinary knowledge, technological and scientific knowledge, capable of stimulating intellectual development in the lifelong learning of its students. In the University environment, for example, Nursing creates conditions for the dissemination of knowledge, teaching, learning, research and experimental development (Law Nº. 62/2007, 2007), and HFCS as a technological resource is valued by the educational community to develop cognitive and psychomotor skills, preparing its students for the processes of practice and education in health.

Health education is distinguished by its ability to train people to care for people with an emphasis on the construction process, allowing the creation of pedagogical practice conducive to the needs of the learners.

2 HIGH-FIDELITY SIMULATION IN HEALTH EDUCATION

High-fidelity clinical simulation (HFCS) has been progressively gaining significant ground within the educational community. Several studies document this growth and the impact that HFCS has on the teaching/learning process and the development of new knowledge for human care. One example is the integrative review developed by Oliveira et al. (2014), which included 54 articles and highlighted HFCS as an essential focus for the development of knowledge and technical and human skills.

The educational path in health is vast and complex, given the unique nature of everyone, increasingly requiring convergent responses that echo holistic practice, seeking to create a learning experience conducive to continuous improvement. Currently, SCAF laboratories create special conditions for meaningful learning (Martins, et al., 2012), and in this sense, students of the Nursing Degree Course at the University of Madeira (UMa), within the framework of the interinstitutional protocol between the University and the Clinical Simulation Center of the Autonomous Region of Madeira, can, during their educational activities, develop their simulated practices in a high-fidelity laboratory. This experience constitutes added value, as it provides students with a moment prior to their experience in a clinical context, safeguarding the comfort and safety of the individual, family, and community in real-world settings.

The HFCS (School-Based Learning and Assessment) aims primarily to promote the development of transversal skills in health and to evaluate student satisfaction with the training process. Satisfaction is a significant indicator, as it is associated with greater engagement and motivation for learning (Martins et al., 2014). In fact, an educational process strengthened by innovative pedagogical practice stimulates satisfaction (Fonseca, 2021) and promotes greater active involvement, using essential tools such as information and communication technologies (Jonassen, 2000). HFCS clearly promotes meaningful learning; however, some (residual) studies do not show these benefits when compared to other teaching-learning strategies (Batista et al., 2014). In health education, numerous pedagogical strategies emerge that aim to develop technical, relational, and human skills, stemming from the mission of excellence and continuous improvement of processes. It is essential to provide a space prior to practical experiences, and the HFCS environment is equipped to improve performance levels, increase the safety of educational processes, and promote the development of individual and collective skills, aiming to reduce the gap between evidence and practice.

2.1 A HEALTH EDUCATION EXPERIENCE WITH HIGH-FIDELITY SIMULATORS

The experience with the HFCS operated seeks to list the steps recommended for the development of clinical scenarios according to the International Nursing Association for Clinical Simulation and Learning committee in 8 essential phases (INACSL, 2016; Martins et al., 2014; Kaneko & Lopes, 2019):

Phase 1 - Meeting between the teacher and the professional simulation centre, with the objective of developing an HFCS plan.

Phase 2 – Selection of scenarios, with a high level of realism, complete, with increasing difficulty, suitable for the stage of academic development and the preparation of the room and specific simulators.

Phase 3 – Conducting a workshop lasting 6 hours of theoretical training, distributed in three thematic sessions lasting 120 minutes each: with a focus on “caring for a person with a stroke”, “caring for a person in the postoperative period after gastrectomy” and “caring for an adult with asthma”.

Phase 4 - Briefing with the mission of explaining the objectives and details of the simulation experience to be developed.

Phase 5 – Development of the simulated practice in a team of two members and under the supervision of a teacher/specialist with the mission of enhancing performance, teamwork, leadership, communication and decision-making in the clinical process.

Phase 6 - Debriefing, a moment of reflection after each scenario, lasting 30 minutes, allows the student to self-evaluate and reflect on possible improvement actions, namely: the overall assessment of the experience's performance, the balance regarding the interventions correctly developed and the key points relating to the simulated clinical experience.

Phase 7 - Evaluation of the educational experience, namely satisfaction with the simulated experience (practical dimension, realism dimension and cognitive dimension) and the debriefing (psychosocial value, value cognitive and affective value).

HFCS aims to enable learners to create their own objectives, empowering them for a practice that generates new opportunities and skills (Jonassen, 2000). Offering students/learners the autonomy to define their own learning objectives enhances the development of reflective, critical, and creative thinking and stimulates a personalized learning practice that generates new learning opportunities (Jonassen, 2000; Vygotsky, 1991).

HFCS establishes itself as a privileged space to explore learning processes in simulated scenarios, and with the use of robotics, under the guidance of a mediator, it enhances the growth of new knowledge in a continuous, more proactive, and mobilizing learning process.

The planning phase of HFCS, phases 1 and 2, is operationalized with a meeting between the team, the professor, and the experienced nurse practitioners in the Clinical Simulation Center and with high-fidelity simulators, assessing a plan suitable for the professional development of the students, creating conditions for the active participation of the professor/mediator in the planning process that promotes the development of cognitive abilities (Jonassen, 2000; Vygotsky, 1991).

The HFCS experience is intentional, organized, and structured, in which the educational institution managed the teaching-learning strategy (Fonseca, 2021). Although with a pre-determined curriculum, the phenomena under study were transformed into a scenario, integrated into real life, seeking to engage the student in action, namely in finding solutions to problems (Martins et al., 2014). At this stage of the process, they emphasize the student's involvement in planning the simulation, which requires greater commitment and adaptation of the scenarios to the needs (INACSL, 2016; Kaneko & Lopes, 2019), thus seeking to stimulate metacognition of practical experiences (competence within the scope of skills) and self-learning (Fonseca, 2021).

Conducting a workshop represents a moment of theoretical training on the scenarios that will be developed; that is, the professor/supervisor selects the specific themes targeted by a clinical simulation and creates the opportunity for students to review and critically analyse knowledge about the phenomenon being simulated. In addition to providing guidance on the simulated environment and available resources, we believe it is fundamental that students at this stage of the process express their expectations and experiences in practical contexts, in order to recreate cases based on these experiences, allowing for learning reflection during the experiences at HFCS (INACSL, 2016; Kaneko & Lopes, 2019).

In phase 4, students are informed about the objectives and the simulation experience to be developed. This phase dedicates significant time to presenting the scenario, known as the briefing, which allows for the description of all the stages the scenario will unfold, fostering an environment of trust and engagement in the simulation experience. Furthermore, it is crucial that the learning facilitator encourages student autonomy in defining objectives and designing the simulation (Fonseca, 2021), creating opportunities to define personal goals and anticipate possible outcomes, not only through reflective and critical thinking but also through creative thinking (Jonassen, 2000; Vygotsky, 1991), encouraging them to argue and express their ideas.

Students develop the simulation experience in teams (two students per team) under the guidance of the learning facilitator, in phase 5. The simulation scenario presented to the students, based on a clinical case in the scientific field, allows them to use the nursing process as a methodological tool, that is, assessment, diagnosis, intervention planning, intervention, evaluation of results, and record keeping. Prior experience and knowledge promote motivation, a proactive attitude, involvement, and satisfaction (Martins et al., 2012). In developing the scenario, the student is confronted with the need to solve problems, and the implementation of the process may stimulate their critical and creative spirit in the search for solutions, revealing knowledge that has not yet been validated or made conscious (Jonassen, 2000).

During the debriefing, phase 6, it emerges as a space for the student to analyse their performance, and for the supervising teacher to reformulate possible actions for improvement, that is, to evaluate the performance of the entire simulated practice. Effectively, it constitutes a criterion of good practices; however, it is fundamental to provide space for students to identify their main learnings, facilitating factors, difficulties, and strategies they used to overcome them, to share their thoughts, feelings, uncertainties, and limitations in their ability to act, and thus learn from the group's experiences (Bortolato-Major et al., 2019; Moliterno et al., 2024). In this way, the teacher would promote a harmonious, affective, and mutually trusting climate, facilitating reflective thinking and a relationship between emotion and reason inherent in human learning (Vygotsky, 1991).

Debriefing is considered a critical aspect of simulation in the educational process. It is a process by which the team can (re)examine whether clinical simulation promotes clinical reasoning and critical thinking (Coutinho et al., 2014, p.161).

While debriefing is a complex activity, it is fundamental for the construction of self-directed knowledge (Martins, 2014). Debriefing emerges as a space where the student exercises their critical capacity in conjunction with the learning facilitator and constitutes a moment of good practices in the educational process of simulation. However, we believe it constitutes a learning moment to create the opportunity for students to identify their main knowledge, facilitating factors of learning, difficulties and strategies they use, share their feelings, uncertainties and limitations in their ability to act, and thus learn from their experiences (Bortolato-Major et al., 2019; Moliterno et al., 2024). The debriefing space also provides interaction with the experiences lived by the participants in the simulation process, given that it allows the sharing of reflections and knowledge, fostering an important social behaviour of the learning experienced in the context (Correia, 2011).

The evaluation of teaching practice by students, staff, teacher, and nurses in practice represents a criterion of good practices in simulation (Kaneko & Lopes, 2019) and can demonstrate that the professor valued the opinion of students and partners with a focus on the continuous improvement of the teaching-learning process. Several authors refer to the importance of evaluating not only student satisfaction with the simulation and debriefing, but also the development of clinical skills, promoted through an objectively structured clinical examination (Batista et al., 2014; Kaneko & Lopes, 2019).

The learning resulting from simulation is useful not only for academic development, but above all for the acquisition of scientific, technical, and human skills for a health culture grounded in ethics, safety, and quality of care (Martins et al., 2012; Bortolato-Major et al., 2019).

Bringing HFCS (Clinical Simulation Environments as a Learning Environment) into the discussion, as a constructive learning environment for knowledge acquisition, constitutes an intentional objective. The perspective of a curriculum-as-life can find a space to promote meaningful learning capable of fostering the development of each student's abilities. As Sousa (2020) emphasizes, considering the postmodern era, a curriculum-as-life is also possible in HFCS learning environments, placing students at the center of the learning processes, with critical expression, as agents of social, political, environmental, and cultural change, that is, protagonists of revolution (Freire, 2013). The fact is that in clinical simulation environments, content is transferred from the teacher/specialist to the student and, from this perspective, the development of HFCS can also be understood as a "bank deposit," guided by a theme, in which students are committed to simulating it to achieve the proposed objectives (Freire, 2013).

The student thus plays a passive role in the learning process, conditioned by the "designer" of the simulation project, who aims to shape the student towards a specific outcome. In this sense, the learning experience is conditioned in the transition from strengthened and math-centered processes, that is, there are limitations in valuing the student, conditioning them to idealize and create their own learning project, that is, to develop their knowledge (Silva, 1999).

Knowledge is always knowledge; there is no clear separation between the act of knowing and what is known, that is, it is "intentional" and is always directed towards something (Freire, 2013). From Freire's perspective, it is the students' experience that becomes the primary source of the "significant themes" that will constitute the "programmatic content," and in this convergence, it makes perfect sense to integrate students in all phases of the HFCS process, fundamentally in the project phase, creating conditions for empowerment to develop naturally.

HFCS constitutes an action activity and, as a pedagogical strategy that generates meaningful learning (Bortolato-Major et al., 2019; Martins et al., 2012), promotes the activation of higher-level thinking processes (critical and creative) in students, especially during the debriefing phase.

In the HFCS learning environment, the development of a meaningful task is identified, based on a teaching-learning process that is triggered through intentional pedagogical intervention and from a real context, promoting student involvement. The teaching-learning strategy at HFCS can be understood as innovative, given that it provides a process of knowledge construction based on the student's own perceptions and conceptions of the world, aiming at the development of learning (Martins et al., 2012; Oliveira et al., 2014), that is, a socio-constructivist, creative learning context adapted to traditional models, promoting autonomy and student involvement as the central agent of the process, which fosters plural communication and the sharing of reflections.

Health education has developed over time, naturally evolving as a necessity of practice, absorbing knowledge from didactics, mathematics, and pedagogy. On the other hand, practical and simulated teaching in the school context is also an example of this evolution (Martins et al., 2012). The pedagogical experiences developed at HFCS constitute opportunities for students to respond to emerging needs in the art of providing good and quality care, stimulating growth at a personal, cultural, scientific, social, ethical, and reflective level, and empowering them for responsible and safe decision-making.

3 CONCLUSION

Health education has evolved significantly in recent years. On the one hand, the discipline has been supported by capable and more comprehensive theories to meet the needs of the community it serves; on the other hand, the emerging development of new, more effective pedagogical techniques that promote more meaningful learning has also evolved remarkably.

The HFCS, equipped with technology, creates a simulation environment like the real-world context of practice. Furthermore, the educational processes developed at HFCS during educational experiences have allowed for the construction of new knowledge and fostered the development of research, teaching/learning, and innovation, as well as the training of professional skills in a controlled, safe, and realistic environment. Several specialties can be explored in educational activities, namely the need for care for individuals experiencing health/illness processes in the respiratory, gastrointestinal, circulatory, integumentary, and neurological systems, as well as health/illness experiences in children. We also highlight the

experiences of simulated practices in family care and community processes, as well as the area of intra- and extra-hospital emergency/urgency care and the care of individuals in surgical and palliative care settings.

The integration of HFCS as a pedagogical strategy in training curricula at the health education level is evident, creating conditions for better learning, training, research, and improvement of professional skills in clinical practice.

The mission of health education is to develop pedagogical activities and enhance clinical training and professional skills development, contributing to continuous improvement and quality assurance. In this regard, the HFCS developed aligns with the integration of curricula in partnership with the training of professionals at the undergraduate and postgraduate levels, and in this context, educational partnerships aimed at developing meaningful learning are of great interest.

The physical spaces in the high-fidelity clinical simulation laboratory resemble the spaces of the real practice context (wards, consultation rooms, resuscitation rooms, minor surgery room, operating theatre, intensive care unit), including all the necessary equipment, hospital beds, technical assistance equipment, auxiliary diagnostic equipment and monitoring equipment.

The HFCS is considered a fundamental resource to enhance safe and risk-free practice, creating conditions to promote continuous improvement of technical and human skills in the construction of health processes, ensuring conscious and scientifically based decision-making, that is, it prepares students to solve complex problems in clinical decision-making.

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SPATIAL SYNTAX AS A MORPHOLOGICAL APPROACH
SINTAXE ESPACIAL COMO UM ABORDAGEM MORFOLÓGICA
LA SINTAXIS ESPACIAL COMO ENFOQUE MORFOLÓGICO



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ABSTRACT

Space Syntax (SS), grounded in the "social logic of space," investigates how urban configuration shapes human behavior and social interactions. This research conducted a bibliometric analysis between 2020 and 2026 in the Web of Science, Scopus, and SciELO databases, using Bibliometrix software to map the scientific production in the field. The results reveal an expanding field, totaling 146 articles and an annual growth rate of 4.91%. A clear geographical shift in production is observed, with China and Australia leading in citation volume, indicating a decentralization from the original European axis. The content analysis of the most relevant publications highlights the integration of SS with hybrid methodologies, such as GIS and Network Analytic Process, applied to themes of public health, socio-spatial equity, and revitalization of historical districts. Seminal studies propose a paradigmatic transition to "evidence-based design," using quantitative and predictive models to optimize urban planning. However, researchers point to limitations in conventional axial modeling, suggesting the refinement of methods to better represent effective accessibility and metric distance. It is concluded that SE is a robust and interdisciplinary scientific tool, essential for understanding and managing the complexity of contemporary urban dynamics.

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Keywords: Urban Morphology. Spatial Syntax. Bibliometrics.

RESUMO

A Sintaxe Espacial (SE), fundamentada na "lógica social do espaço", investiga como a configuração urbana molda o comportamento humano e as interações sociais. Esta pesquisa realizou uma análise bibliométrica entre 2020 e 2026 nas bases *Web of Science*, *Scopus* e *Scielo*, utilizando o software *Bibliometrix* para mapear a produção científica da área. Os resultados revelam um campo em expansão, totalizando 146 artigos e uma taxa de crescimento anual de 4,91%. Observa-se um claro deslocamento geográfico da produção, com a China e a Austrália liderando em volume de citações, indicando uma descentralização do eixo europeu original. A análise de conteúdo das publicações mais relevantes destaca a integração da SE com metodologias híbridas, como o SIG e o Processo Analítico em Rede, aplicadas a temas de saúde pública, equidade socioespacial e revitalização de distritos históricos. Estudos seminais propõem uma transição paradigmática para o "design baseado em evidências", utilizando modelos quantitativos e preditivos para otimizar o planejamento urbano. Contudo, pesquisadores apontam limitações na modelagem axial convencional, sugerindo o refinamento dos métodos para melhor representar a acessibilidade efetiva e a distância métrica. Conclui-se que a SE é uma ferramenta científica robusta e interdisciplinar, essencial para compreender e gerenciar a complexidade das dinâmicas urbanas contemporâneas.

Palavras-chave: Morfologia Urbana. Sintaxe Espacial. Bibliometria.

RESUMEN

La Sintaxis Espacial (SS), fundamentada en la «lógica social del espacio», investiga cómo la configuración urbana moldea el comportamiento humano y las interacciones sociales. Esta investigación realizó un análisis bibliométrico entre 2020 y 2026 en las bases de datos *Web of Science*, *Scopus* y *SciELO*, utilizando el software *Bibliometrix* para mapear la producción científica en el campo. Los resultados revelan un campo en expansión, con un total de 146 artículos y una tasa de crecimiento anual del 4,91 %. Se observa un claro cambio geográfico en la producción, con China y Australia a la cabeza en volumen de citas, lo que indica una descentralización del eje europeo original. El análisis de contenido de las publicaciones más relevantes destaca la integración de la SS con metodologías híbridas, como SIG y el Proceso Analítico de Redes, aplicadas a temas de salud pública, equidad socioespacial y revitalización de distritos históricos. Estudios fundamentales proponen una transición paradigmática hacia el «diseño basado en la evidencia», utilizando modelos cuantitativos y predictivos para optimizar la planificación urbana. Sin embargo, los investigadores señalan las limitaciones del modelado axial convencional, sugiriendo el perfeccionamiento de los métodos para representar mejor la accesibilidad efectiva y la distancia métrica. Se concluye que la sintaxis espacial es una herramienta científica robusta e interdisciplinaria, esencial para comprender y gestionar la complejidad de la dinámica urbana contemporánea.

Palabras clave: Morfología Urbana. Sintaxis Espacial. Bibliometría.

1 INTRODUCTION

Spatial Syntax (SE) is a field of theoretical and methodological research that proposes an innovative vision of architecture and urbanism. Originating in the early 1970s at the Architectural Studies Unit at University College London, the theory was consolidated by researchers Bill Hillier and Julienne Hanson. The central objective of the SE is to establish a descriptive autonomy of space, allowing the morphological variety of cities to be analyzed in terms of their direct relationship with social life and patterns of human behavior.

The epistemological framework of Spatial Syntax was formalized mainly in the work *The Social Logic of Space* (1984). In this book, Hillier and Hanson present space not only as a passive receptacle of activities, but as an active dimension of society. The theory argues that there are cultural and social traits determined by spatial patterns, with a transition between physical configuration, spatial life and, finally, social life. Thus, the system of open spaces is seen as a continuous set of identifiable elements that structure social encounters and land use patterns.

To operationalize these analyses, the SE uses techniques for decomposing the system into convex spaces and axial spaces, resulting in convexity and axiality maps. These abstractions allow us to reveal fundamental attributes of the urban environment and correlate the built form with social and behavioral concepts. In addition, the theory uses graph theory to represent spatial configurations logically: each space is treated as a "node" and its connections as "lines". Through the concept of justified graphs, researchers can organize the system into depth levels by measuring the topological distance between spaces from a reference point or "root".

In this way, Spatial Syntax is consolidated as a robust set of analytical tools that allow a descriptive analysis of urban sectors or buildings. By focusing on the social logic of space, the SE offers a scientific basis for understanding how spatial structure shapes the dynamics of cities and the interactions of their inhabitants. According to Karimi (2023), in order to understand the current state of urban morphology as a distinct academic domain, it is essential to explore the diversity of approaches that have emerged over the last century. Regardless of their specific focuses, these approaches can be broadly grouped.

According to Silva (2025), there are criticisms of the theory of spatial syntax, such as that the analysis is more topological than geometric and the problem of continuity of axial lines, but applications have tried to solve these issues and there has been an increasing approximation between topological and geometric analysis.

2 METHODOLOGY

The method used in the research was descriptive, which aims to transcribe, describe, interpret and explain the results obtained with the help of bibliometric analysis. This aims to identify and analyze the profile of the scientific production of a given topic, making use of the quantitative approach through descriptive statistics. The databases used were the Web of Science, Scielo and Scopus, which are available on the journal portal Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). These databases have databases of abstracts and citations of peer-reviewed literature, including scientific journals, books, and conference proceedings, which cover topics from various areas of knowledge. The search was carried out on 04/22/2026, covering the period from 2020 to the year 2026. The terms used were searched in the title, abstract, and keywords of the articles. The search was restricted to articles from open journals. The query syntax in the databases was as follows: "*urban morphology and spatial syntax*". The main search was through this keyword, restricting the search to only the articles.

The data related to these documents (journals, authors, references, citations, etc.) were stored in a text file for performance analysis and bibliometric mapping. The descriptive analysis and mapping were performed by the Bibliometrix software, which is part of RStudio, which is the most popular integrated development environment (IDE) for the R programming language, being widely used in data science, statistics and academic research.

The method of analysis of the empirical objects will follow three main phases organized as follows: Preparatory phase: Cut out the theme and keyword for the research (urban morphology and spatial syntax); Search in databases (web of Science and Scopus); Export the data to the Bibliometrix application in RStudio; Generate quantitative data tables and graphs in Bibliometrix; Analytical phase: Review of the literature on the subject; Grouping of quantitative data in tables and graphs generated in Bibliometrix; Bibliometric analysis; Descriptive phase: Interpretation of the results found in the Bibliometrix.

3 BIBLIOMETRIC ANALYSIS

The objective of this section is to analyze the performance of bibliometric results, considering some aspects, such as the annual scientific production, the evolution of citations, relevant sources and authors, world scientific production and the bibliometric networks that most collaborate with each other in scientific productions on the theme transition of institutional paradigms and sustainability. Table 1 shows the main data on this survey in the period from

2020 to 2026. 146 documents with 399 authors involved and 20,986 references were found in the databases (web of Science, scielo and scopus).

Table 1

Summary of the survey data

Key information about the survey data	
Description	Results
Time Range	2020/2026
Sources (newspapers, books, etc.)	93
Documents (articles)	146
Annual growth rate (%)	4,91
Average document age	2,6
Average citations per document	10
Authors	399
Most used keywords (ID)	457
Keywords by author (DE)	350

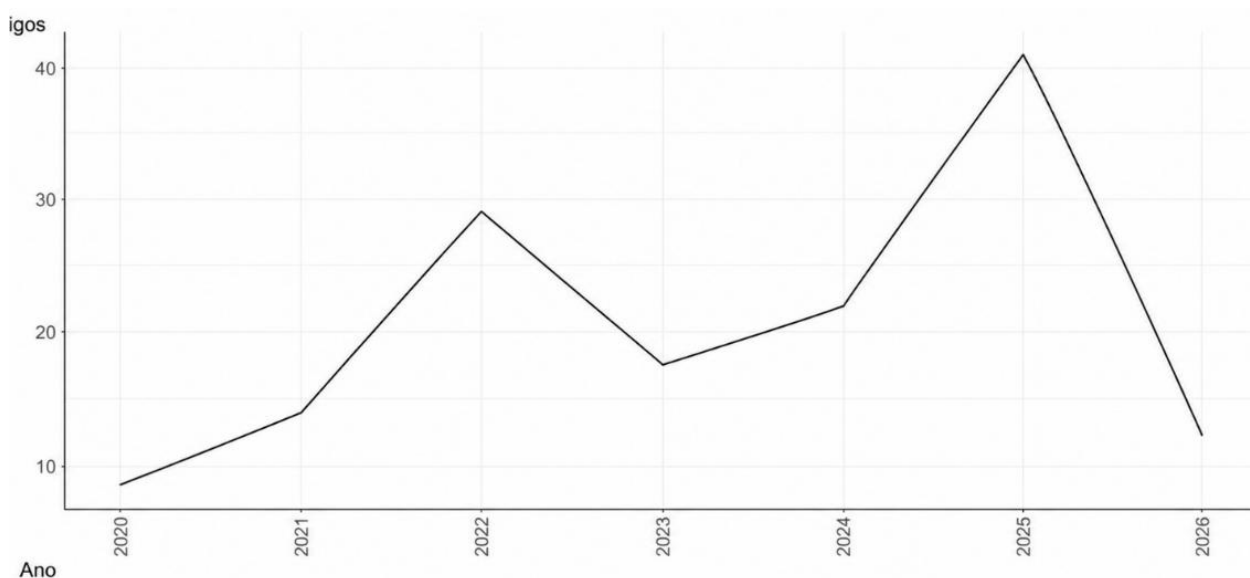
Source: Result of the Web of Science, Scopus, Scielo search, obtained from Bibliometrix (2026)

4 ANNUAL SCIENTIFIC PRODUCTION

Figure 1 shows the evolution of the number of publications from 2020 to 2026 on the topic of urban morphology and spatial syntax. It can be identified that in 2020 there are approximately 7 articles published, with a noticeable increase in 2022 to almost 30 articles, tripling, compared to 2020. In 2025 there was an increase of 10 articles compared to 2022. In the year 2026, due to being still at the beginning, the number of publications was not so expressive, being around 15 publications.

Figure 1

Annual scientific production



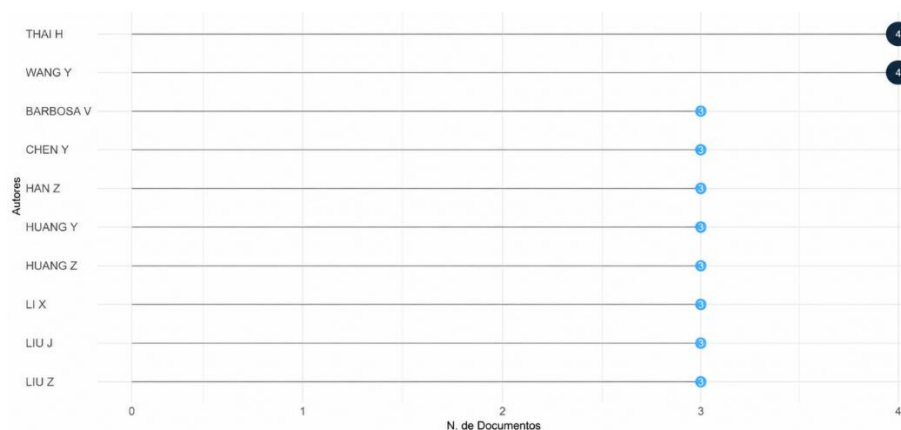
Source: Result of the Web of Science, Scopus, Scielo search, obtained from Bibliometrix (2026)

5 MOST RELEVANT AUTHORS

The ten authors, who published the most on the theme of urban morphology and spatial syntax, can be seen in figure 2, where it identifies the researchers with the greatest impact and academic production on the researched theme within the selected databases (Web of Science, Scopus, Scielo). Thai HMH and Wang are the most relevant with 4 publications and an impact factor of $H=1.67$ and 1.12 respectively. In second place, the author Barbosa and the others with 3 articles each.

Figure 2

Most relevant authors

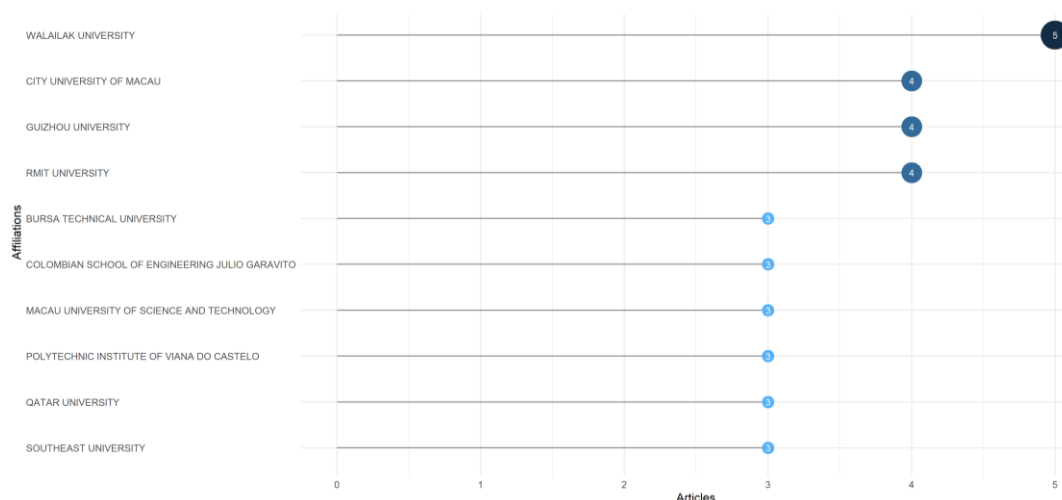


Source: Result of the Web of Science, Scopus, Scielo search, obtained from Bibliometrix (2026)

6 MOST RELEVANT AFFILIATIONS

Figure 3

Most relevant affiliations



Source: Result of the Web of Science, Scopus, Scielo search, obtained from Bibliometrix (2026)

Figure 3 shows the ten most relevant affiliations on the topic in question. Walailak University ranked first with 5 publications.

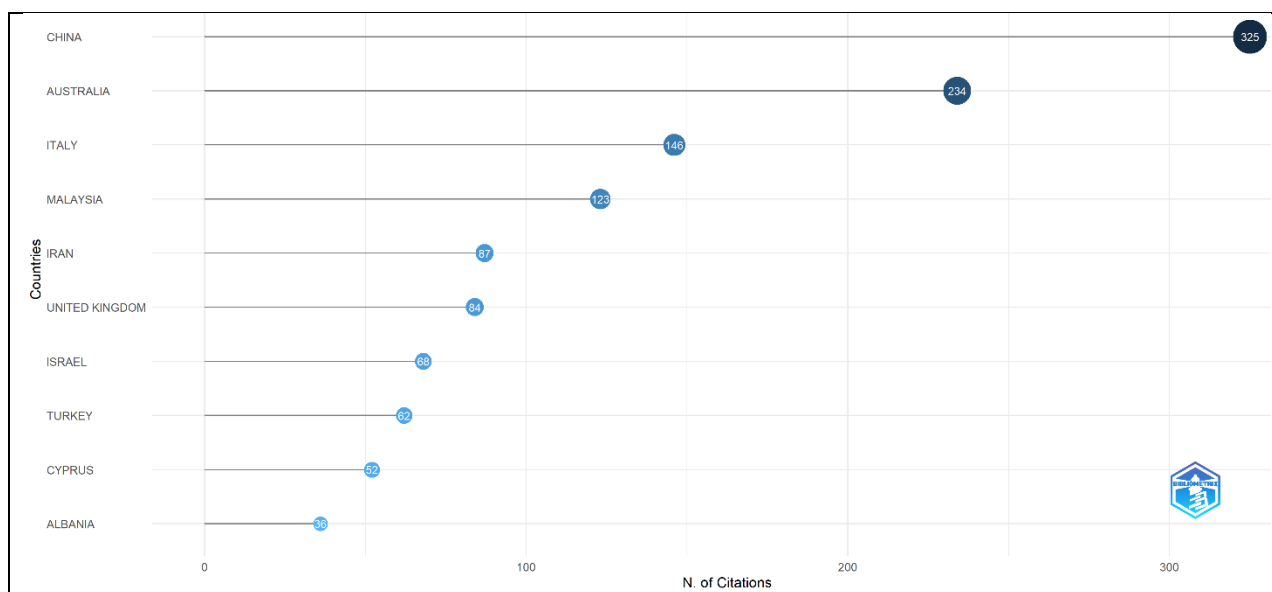
The City University of Macau, University of Guizhou and Rmit University with 4 were second. Bursa Technical University, Julio Garavito Colombian School of Engineering, Macau University of Science and Technology, Polytechnic Institute of Viana do Castelo, Qatar University and Southeast University in third with 3 publications each. The results corroborate the importance of collaborative bibliometric networks between institutions, where researchers are linked.

7 SCIENTIFIC PRODUCTION OF COUNTRIES

Figure 4 shows the situation of scientific production in the countries in relation to the authors who published on the subject. It is noted that there is a progressive increase, showing that China and Australia have been standing out with 325 and 234 respectively, closely followed by Italy with 146 mentions and Malaysia with 123. Iran appears in fifth place with 87 citations, closely followed by the United Kingdom, where the theory of spatial syntax was created, with 84 citations, demonstrating a shift in the study of this theme from the European continent (England) to other continents, such as Asia, Oceania and the Middle East (Iran, Israel, Turkey and Cyprus).

Figure 4

Most cited countries

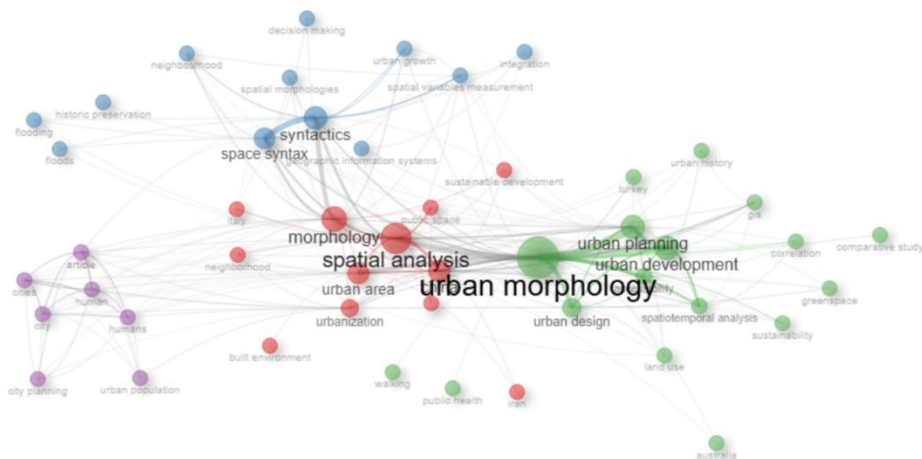


Source: Result of the Web of Science, Scopus, Scielo search, obtained from Bibliometrix (2026)

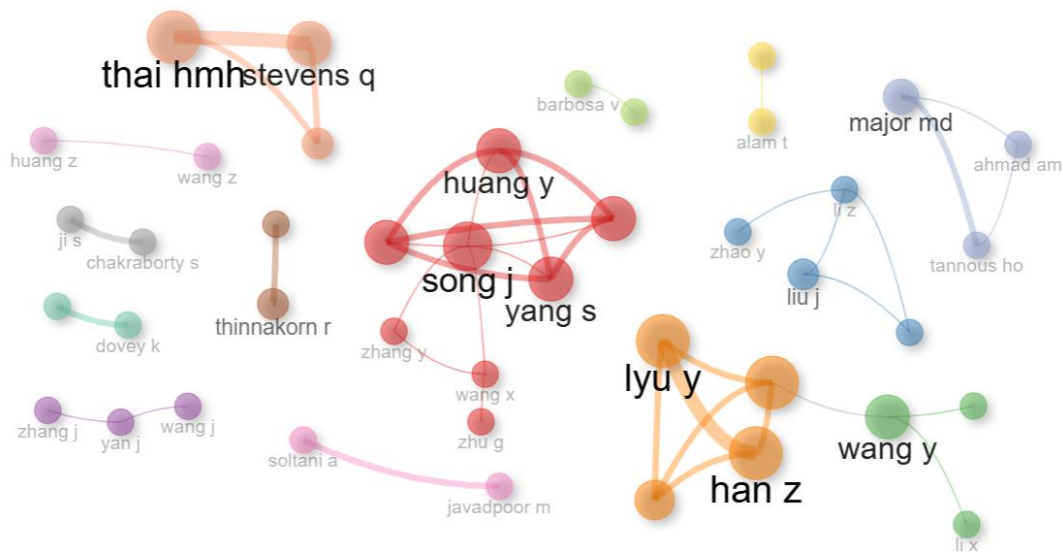
8 BIBLIOMETRIC NETWORKS

Figure 5 shows the network of co-occurrence of the keywords; in it, the following are observed: the most frequent terms, with the occurrences proportional to the size of the circles and label; the associations between the words, given by the links and proximity; the groups, indicated by the colors. In this network, four groups were formed, three of which stood out the most: the green cluster, representing the occurrence of the terms *urban morphology*. The cluster represented by the color blue identified the highlighted terms *syntactics* and *space syntax*. The red cluster stood out with the keywords *spacial analysis and morphology*. It was observed that, although each group has a specific theme, these groups research very similar themes and connections and integrations occur more frequently, forming a large bibliometric network.

Figure 5
Co-occurrence networks



Source: Result of the Web of Science, Scopus, Scielo search, obtained from Bibliometrix (2026)

Figure 6*Collaboration networks by author*

Source: Result of the Web of Science, Scopus, Scielo search, obtained from Bibliometrix (2026)

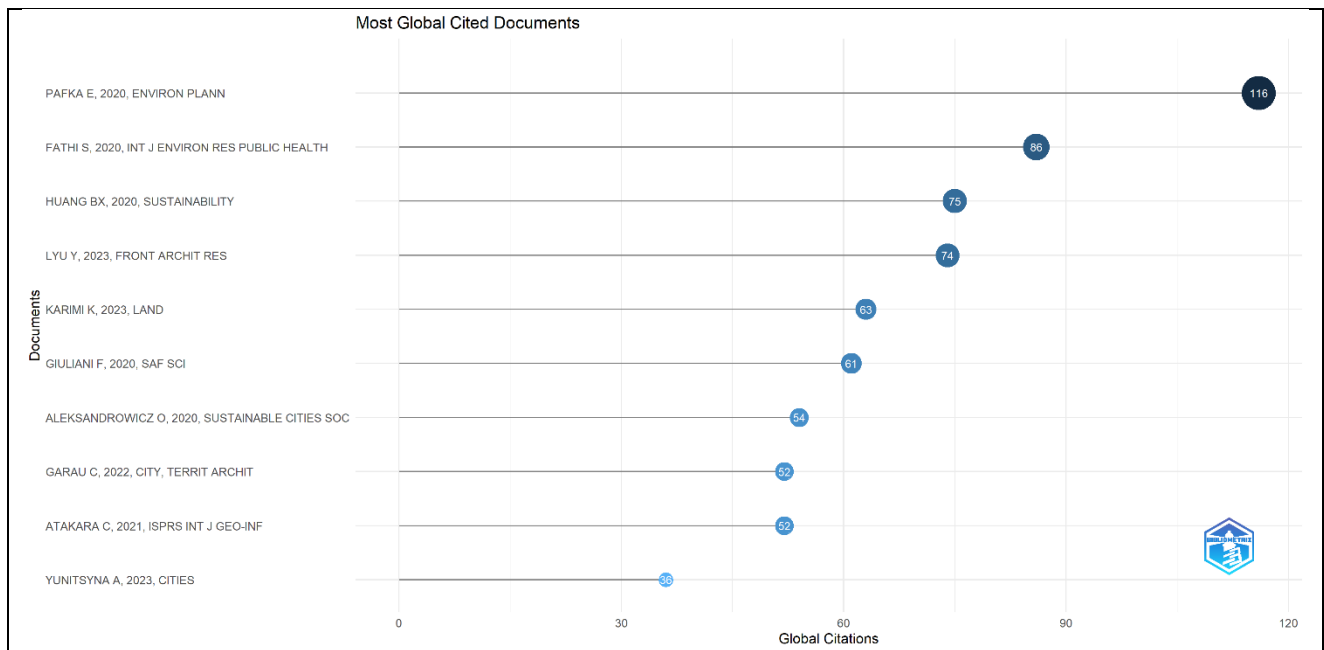
Figure 6 shows the network of collaboration between the researchers, forming 14 small groups represented by circles of different colors. The collaboration network represented by the color red is the one that stood out the most, both in terms of the number of members, with the size of the circles increased, and in the quantity, in relation to the other groups. It is noteworthy that the collaboration groups do not connect much with each other. This means that collaboration networks can grow even more if connections and integration increase.

9 CONTENT ANALYSIS OF THE EIGHT MOST RELEVANT AND GLOBALLY CITED PUBLICATIONS

In this topic, the content of the abstracts of the eight most relevant and globally cited articles found in this bibliometric review was analyzed, and most of the findings identified a strong use of the theory of spatial syntax in the study of urban morphology and urban planning (Figure 7). In the samples examined, it was observed that the researchers used the bibliographic references produced over time, as well as empirical and statistical studies to support their research, which contributed to increase the confidence and security of the results presented. In these terms, with the purpose of verifying which articles published in journals, aroused the interest of researchers.

Figure 7

Most cited documents globally



Source: Result of the Web of Science, Scopus, Scielo, Bibliometrix survey (2026)

The first article *Limits of space syntax for urban design: Axiality, scale and sinuosity* addresses the limits of spatial syntax for urban planning, considering axiality, scale and sinuosity. The authors of this research are Pafka, Dovey and Aschwanden (2020) with 116 citations. The researchers maintain that the exegesis of spatial syntax from the perspective of the economy of movement has deepened the understanding of urban structure, correlating systemic integration with vitality and functional diversity. However, conventional axial modeling has limitations by neglecting metric distance and morphological roughness variables.

According to Pafka, Dovey and Aschwanden (2020), the evidence suggests that adaptations in axial methods generate heterogeneous results for the same morphology. The dichotomy between closeness and betweenness indicates that network integration is a multidimensional phenomenon. It is concluded that purely axial analyses tend to privilege the hegemony of visibility over effective accessibility, which can compromise the accuracy of the representation of permeability on a pedestrian scale. They state that spatial syntax analysis is a powerful tool that will be even more useful the better these boundaries are understood.

The second article with 86 citations, called *The Role of Urban Morphology Design on Enhancing Physical Activity and Public Health*, which deals with the role of urban morphology planning in the promotion of physical activity and public health. The researchers FATHI, SAJADZADEH, SHESHKAL, ARAM, PINTER, FELDE, MOSAVI (2020) maintain that the contemporary literature ratifies the correlation between the configuration of the built

environment and public health indicators, underlining the role of urban morphology in mitigating psychopathologies and inducing healthy behaviors. This study investigates the promotion of active mobility through the functional and physical optimization of the urban fabric.

Using a hybrid methodological approach — which integrates the Network Analytical Process (ANP), structural equation modeling, and spatial syntax — the research identifies that systemic integration, diversity of uses, and aesthetic quality are significant predictors of physical engagement. The findings demonstrate that road axes with high levels of syntactic connectivity operate as catalysts for physical activity and subjective well-being, validating spatiality as a determining asset in the promotion of urban health.

The third document *Accessibility and Street Network Characteristics of Urban Public Facility Spaces: Equity Research on Parks in Fuzhou City Based on GIS and Space Syntax Model* with 75 citations deals with Accessibility and characteristics of the road network of urban public spaces, researching equity in parks in the city of Fuzhou using GIS and spatial syntax model. Huang, Chiou, and Li (2020) elucidate the positive correlation between urban green spaces and the holistic well-being of the population, showing, however, disparities in the socio-spatial distribution of these benefits. The research applies the Geographic Information System (GIS) and spatial syntax to measure equity and urban morphology in Fuzhou, providing empirical subsidies for the planning of sustainable cities.

The fourth article discussed *Unveiling the potential of space syntax approach for revitalizing historic urban areas: A case study of Yushan Historic District, China* contains 61 citations. LYU, MALEK, JA'AFAR, SIMA, HAN, and LIU (2023) Demonstrate in research the potential of the spatial syntax approach to revitalize historic urban areas through the case of the Yushan Historic District, China. The authors state that historic urban areas constitute primordial elements of heritage, safeguarding collective memory and unique morphologies. However, globalization brings challenges such as infrastructural obsolescence and the erosion of cultural vitality. This research proposes a revitalization methodology based on spatial syntax, applied to the Yushan Historic District. Through morphological modeling, the study identifies spatial determinants of vitality and proposes strategic guidelines that reconcile functional renewal with the preservation of the historical fabric, validating the potential of spatial syntax in heritage conservation.

The fifth article *The Configurational Structures of Social Spaces: Space Syntax and Urban Morphology in the Context of Analytical, Evidence-Based Design* was published in 2023 by researcher Kayvan Karimi from the Bartlett School of Architecture, UCL, London, UK. Karimi

(2023). It explores the Configurational Structures of Social Spaces using the approach of Spatial Syntax and Urban Morphology in the Context of Evidence-Based Analytical Design.

The article postulates a paradigmatic transition in urban morphology, migrating from purely descriptive analyses to quantitative and predictive investigations based on spatial syntax. The proposed approach integrates socioeconomic and cultural determinants into the physical configuration, enabling the development of evidence-based designs. Through an iterative methodological cycle applied in Jilin, a city in China, it is demonstrated how analytical spatial analysis optimizes infrastructure and transport planning. Ultimately, the integration of this tool empowers planners to manage the complexity of urban systems, ensuring the relevance of interventions in the face of the dynamics of human existence and ever-evolving physical structures.

In the sixth publication, Giuliano, Cutini (2020) address the management of post-earthquake emergencies in Italian historic centers, exemplified by the case of Lucignano. The research highlights that the morphology of these settlements is often neglected in traditional risk planning, aiming to increase urban resilience in the face of seismic events.

The seventh survey, In the context of **microclimatic comfort**, the methodology applied in Tel Aviv-Yafo uses high-resolution mapping to create "shading maps". Aleksandrowicz, Zur, Lebendiger, Lerman (2020) argue that the differential of the research is to relate the availability of external shade with the potential for pedestrian movement identified by spatial syntax, allowing urban managers to prioritize tree planting or conservation actions on streets.

Finally, Garau's study , Annunziata (2022), focused on the Metropolitan City of Cagliari investigates urban vitality. The research develops a method to quantify how the components of the built environment impact urbanity and the diversity of activities in public spaces. By integrating spatial syntax into the Geodesign paradigm, researchers are able to identify spatial manifestations of socioeconomic processes, providing subsidies to formulate strategies that strengthen urbanity, creating vibrant and sustainable urban spaces.

10 CONCLUSIONS

The objective of this study was to carry out a bibliometric mapping on the theme of urban morphology and spatial syntax. It was observed that there are already a reasonable number of studies that study this theme, but the scientific production still shows evolutionary progress. Based on the bibliometric and qualitative analysis of the documents presented, the conclusions about the current state of research in urban morphology and spatial syntax (SE), between the years 2020 and 2026, it can be noted the academic maturity and expansion, in which the field

demonstrates sustained growth, with an annual growth rate of 4.91% and a significant volume of 146 articles produced in a period of six years. The peak of publications between 2022 and 2025 reflects the consolidation of spatial syntax as a robust set of analytical tools for understanding urban dynamics.

A second aspect found was the geographic decentralization of production, although the theory originated in the United Kingdom, there is a clear shift in the axis of scientific production to Asia and Oceania, with China (325 citations) and Australia (234 citations) leading the academic impact. Institutions such as Walailak University and the City University of Macau are prominent research centers.

The articles demonstrated that interdisciplinarity and methodological integration in contemporary research transcends pure morphological analysis, integrating SE with other advanced methodologies, such as the Geographic Information System (GIS), the Network Analytical Process (ANP) and structural equation modeling. This hybridization allows, for example, to correlate spatial configuration with indicators of public health, social equity, and preservation of historical heritage. It is important to emphasize that the paradigmatic evolution towards evidence-based urban planning identifies a transition from merely descriptive analyses to quantitative and predictive approaches. The use of SE as a decision support tool in urban planning — the so-called "evidence-based design" — allows managing the complexity of urban systems and optimizing transport and active mobility infrastructures.

However, theoretical refinement and limitations are necessary. The most cited studies point to the need to overcome the limitations of conventional axial modeling. Researchers suggest that the SE should evolve to incorporate metric distance and morphological roughness variables, ensuring that visibility analysis does not overlap with effective pedestrian-scale accessibility. The structure of scientific collaboration, despite the density of publications, the networks of collaboration between authors are still fragmented, with groups that are little connected to each other. This indicates a growth potential for future research through increased integration and inter-institutional cooperation. In short, the archive reveals that spatial syntax remains a vital and constantly evolving theory, capable of providing scientific foundations to address contemporary urban challenges through the analysis of the social logic of space.

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BEYOND THE VIRUS: HOW COVID-19 ACCELERATED THE SUICIDE CRISIS IN BRAZIL

PARA ALÉM DO VÍRUS: COMO A COVID-19 ACELEROU A CRISE DE SUICÍDIOS NO BRASIL

MÁS ALLÁ DEL VIRUS: CÓMO LA COVID-19 ACELERÓ LA CRISIS DE SUICIDIO EN BRASIL



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ABSTRACT

The COVID-19 pandemic significantly impacted global mental health, with a noticeable increase in suicide rates. This study analyzes the impact of the pandemic on suicides in Brazil between 2015 and 2023, using a Bayesian time series model to identify the causal relationship between the health crisis and the worsening psychological conditions of the population. The results show a substantial rise in suicide cases starting in 2020, associated with social isolation, economic difficulties, and emotional deprivation. The study highlights the importance of public policies focused on suicide prevention and strengthening social support networks, suggesting that health crises exacerbate mental health issues and require effective responses to minimize their impacts.

Keywords: COVID-19. Suicide. Mental Health. Impact. Brazil.

RESUMO

A pandemia de COVID-19 impactou significativamente a saúde mental global, com um aumento notável nos índices de suicídio. Este estudo analisa o impacto da pandemia nos suicídios no Brasil entre 2015 e 2023, utilizando um modelo bayesiano de séries temporais para identificar a relação causal entre a crise sanitária e a piora das condições psicológicas da população. Os resultados indicam um aumento substancial nos casos de suicídio a partir de 2020, associado ao isolamento social, dificuldades econômicas e privação emocional. O estudo destaca a importância de políticas públicas focadas na prevenção do suicídio e no fortalecimento das redes de apoio social, sugerindo que crises sanitárias exacerbam problemas de saúde mental e exigem respostas eficazes para minimizar seus impactos.

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Palavras-chave: COVID-19. Suicídio. Saúde Mental. Impacto. Brasil.

RESUMEN

La pandemia de COVID-19 impactó significativamente la salud mental global, con un notable aumento en las tasas de suicidio. Este estudio analiza el impacto de la pandemia en los suicidios en Brasil entre 2015 y 2023, utilizando un modelo bayesiano de series de tiempo para identificar la relación causal entre la crisis sanitaria y el empeoramiento de las condiciones psicológicas de la población. Los resultados muestran un aumento sustancial en los casos de suicidio a partir de 2020, asociado con el aislamiento social, las dificultades económicas y la privación emocional. El estudio destaca la importancia de políticas públicas centradas en la prevención del suicidio y el fortalecimiento de las redes de apoyo social, sugiriendo que las crisis sanitarias exacerban los problemas de salud mental y requieren respuestas efectivas para minimizar sus impactos.

Palabras clave: COVID-19. Suicidio. Salud Mental. Impacto. Brasil.

1 INTRODUCTION

1.1 SUICIDE AS A PUBLIC HEALTH PROBLEM

Suicide is a serious global public health problem, being among the main causes of preventable deaths in several countries. In addition to the alarming numbers, this tragedy deeply impacts families, communities, and society as a whole. The emotional and economic effects are particularly devastating in young and adult age groups, making prevention a key challenge for health systems.

In Brazil, suicide rates have been growing over the last few decades, reflecting not only individual factors, but also social and economic issues that contribute to psychological distress and limit access to emotional support resources. Although the Brazilian suicide rate is lower than that of countries such as Russia, South Korea, and Japan, Brazil leads Latin America in negative mental health indicators (MINISTRY OF HEALTH, 2022), highlighting the need for more effective preventive actions. The crisis has been exacerbated by the phenomenon that experts call the "second pandemic" – a silent collapse of mental health, intensified by social and economic changes post-COVID-19 pandemic (FEDERAL COUNCIL OF NURSING, 2023).

The World Health Organization (WHO) warns that suicide is responsible for about one in every 100 global deaths, surpassing fatalities from HIV, malaria, breast cancer, wars and homicides (BRASIL, 2015). In Brazil, suicides in 2023 surpassed other relevant causes of death, such as prostate cancer, AIDS, police interventions, and femicides. In addition, the numbers approached the cases of death from breast cancer, one of the diseases with the greatest impact on public health. These data reinforce the need to deepen knowledge about the factors that contribute to the increase in suicides and to support public prevention policies.

Suicide records in Brazil between 2015 and 2023 demonstrate a continuous growth trend, with a more significant increase in the critical years of the COVID-19 pandemic, suggesting a possible and alarming relationship between the pandemic context and the worsening of the population's mental health. Although the growth in suicide cases was already noticeable before the health crisis, factors such as social isolation, economic insecurity, and difficulty in accessing mental health services certainly accelerated this process. This problem, although not restricted to Brazil, acquires specific characteristics in the country, such as regional inequality and overload of the health system, making it even more crucial to monitor the rates and understand the factors that feed this devastating phenomenon.

1.2 THE COVID PANDEMIC AND ITS IMPACTS

The COVID-19 pandemic, officially declared by the WHO on March 11, 2020, is not only a health crisis, but an extreme event of historic proportions, which has profoundly affected global public health. The speed and severity of the spread of SARS-CoV-2 has resulted in millions of infections and deaths. By the end of 2022, the WHO estimated more than 6.5 million confirmed deaths worldwide, with the possibility that the real number was much higher due to underreporting and excess indirect mortality. Brazil, one of the most affected countries, recorded approximately 700 thousand deaths, second only to the United States. The critical peaks occurred between March and April 2021, when the Brazilian health system collapsed in several regions, facing shortages of ICU beds, oxygen, and essential medicines, a scenario of immeasurable human suffering.

The containment measures adopted to reduce the spread of the virus, such as quarantines, social distancing, and the closure of establishments, have drastically changed the population's routine. While necessary, these restrictions have had a direct and significant impact on mental health, resulting in an alarming increase in feelings of loneliness, anxiety, and depression (CAO et al., 2020; WHO, 2022). The closure of face-to-face psychological and psychiatric care services has further aggravated this situation, making it difficult for the population to access specialized support (CFP, 2020). At the same time, the global economic recession triggered by the pandemic, with the closure of companies and the increase in job insecurity, especially in the tourism, commerce, and services sectors, has further increased the risk of psychological disorders and self-injurious behaviors.

It is important to highlight that the relationship between global crises and the increase in suicide cases is not a recent phenomenon. In times of economic recession, wars, and natural disasters, there has historically been an increase in rates of psychological distress and suicides. The Great Depression of 1929 and the financial crisis of 2008, for example, were followed by significant increases in suicide rates (NEGÓCIOS, 2008). However, the COVID-19 pandemic has had a much deeper and more far-reaching impact, not only because of the economic recession but because of its multidimensional nature, simultaneously affecting the physical, mental, and economic health of billions of people around the world. The magnitude of this crisis, with its devastating effects on all aspects of human life, places it as one of the largest and most significant extreme health events of the twenty-first century.

This work, therefore, is not a simple study of a health crisis, but rather an analysis of a unique event in contemporary history, whose repercussions go far beyond public health. The COVID-19 pandemic cannot be underestimated. It is not just a health event, but a global tragedy

that has affected the lives of millions, and it is essential that the impact of this event be studied in depth to understand its causes, consequences and, above all, to identify solutions that can mitigate the devastating effects on mental health and society as a whole.

It is crucial to recognize that crises of such magnitude are not limited to the COVID-19 pandemic. Other extreme events, such as future pandemics, global economic recessions, and even environmental catastrophes, have the potential to generate similar effects, significantly increasing the risk of psychological distress and suicides. Thus, the key question of this work arises: did the COVID-19 pandemic have an impact on the number of suicides in Brazil and its regions?

The research problem is centered on quantitatively analyzing the effect of the pandemic on the number of people who took their own lives. The importance of analyzing this problem lies in understanding a possible causality between the COVID-19 pandemic and the number of suicides. The present study is based on the hypothesis that the COVID-19 pandemic exerted a significant influence on the increase in suicide numbers, both in Brazil and in its regions.

The general objective of this study is to analyze the temporal and spatial dynamics of suicide rates in Brazil and its regions from January 2015 to April 2023⁴. Specifically, it is intended to: a) analyze the dynamics of the behavior of the suicide rate in Brazil and its regions; b) to identify the possible existence of a causal link between the COVID-19 pandemic and the incidence of suicides in Brazil.

The results may highlight not only the direct influence of the pandemic on the mental health of the population, but also the urgency of adopting a comprehensive approach in the face of extreme events. It is essential to understand that, in addition to mitigating the immediate effects of the event, it is necessary to deal with the lasting psychological impacts by offering ongoing mental health support as part of a global and effective response.

Regarding the causal impacts of public health events on suicide indicators at the regional level, this research is one of the first attempts. The contribution that is intended to be brought is in the quantitative focus of the research, which until now has been little addressed by the existing literature on the subject.

The work is structured as follows: after the introduction, there is the methodology, which contains the theoretical framework, in which a link between theory and research problem is defined, the analytical framework, in which the empirical model is presented, and the data source, in which the variables used and their origin are presented.

⁴ The year 2015 marks the beginning of the historical series on suicide rates in Brazil and April 2023 was chosen as the end of the study, as it marks the end of the pandemic, as declared by the World Health Organization (WHO), given the significant reduction in cases and deaths from COVID-19 in Brazil.

2 METHODOLOGY

2.1 THEORETICAL FRAMEWORK

The Theory of Social Deprivation (WEISS, 1973) lays a crucial foundation for understanding the effects of the absence of meaningful social interactions on people's emotional and psychological well-being. According to Weiss, human beings are essentially social creatures, whose mental health depends on deep and sustainable bonds. The absence of these ties not only generates discomfort, but can also cause a series of negative consequences, increasing the risk of disorders such as depression, anxiety and, in more severe cases, suicidal tendencies. Thus, the theory suggests that prolonged isolation leads to progressive deterioration of mental health, making the individual feel helpless, vulnerable, and lost in the midst of loneliness.

Weiss differentiates between two types of loneliness: emotional and social. Emotional loneliness refers to the absence of an intimate bond, such as a relationship with a partner or close friend, while social loneliness involves the absence of a wider support network, such as family members, colleagues, or neighbors. These two types of deprivation are interconnected in different ways, but both affect mental health, reinforcing feelings of exclusion and disconnection. During modern life, marked by busy schedules and a constant emphasis on productivity, many people experience both types of loneliness, as, although surrounded by people, they lack truly meaningful relationships and a sense of community.

The Theory of Social Deprivation has been widely applied to analyze the effects of isolation in different contexts. A study by Victor and Bowling (2012), in the United Kingdom, showed that older adults in long-term care facilities who did not receive regular visits had significantly higher levels of depression and anxiety compared to those who had frequent contact with family and friends. Another example comes from Haney's (2018) research, which investigated the effects of solitary confinement in prisons in the United States, revealing that prolonged isolation is associated with increased disorders such as post-traumatic stress, hallucinations, and self-injurious behavior.

During the COVID-19 pandemic, the Theory of Social Deprivation has become more relevant than ever. The need to adopt social distancing measures to contain the spread of the virus has generated a crisis of contact deprivation on a global scale. Millions of people have abruptly faced a break with their emotional support circles, whether family, friends or co-workers. The sudden deprivation of physical encounters, touch, and interpersonal closeness exposed the population to significant psychological risks. Studies have revealed increased rates

of depression, anxiety, and suicidal ideation, intensifying the perception that loneliness is not just discomfort, but a real threat to public health.

A study conducted by Meyer et al. (2021), in Germany, indicated that remote work and prolonged isolation contributed to increased feelings of social loneliness, especially among workers without a solid support network outside the work environment. These individuals reported worsening mental health, including symptoms of anxiety and depression.

Thus, Weiss's theory provides a robust framework for understanding how isolation can destabilize the human mind and provoke feelings of despair. During the pandemic, many individuals were deprived of their emotional support networks, facing deep loneliness. Those already vulnerable – such as the elderly and people living alone – were especially affected, experiencing intense emotional loneliness without being able to count on close bonds to help them face adversity. For these people, deprivation has become a triggering factor for psychological disorders and even loss of purpose and hope.

In the Brazilian context, the theory suggests that the increase in isolation during the pandemic directly affected suicide rates. The imposed isolation, combined with economic uncertainty and the absence of adequate support, created a favorable scenario for the worsening of psychological disorders. The theory highlights that the importance of human connections for the maintenance of mental health cannot be underestimated and that the psychic suffering generated by the deprivation of contact is collective, requiring support strategies that involve families, communities and government actions.

2.2 ANALYTICAL FRAMEWORK

To assess the impact of social isolation on suicide rates, the Bayesian structural model of time series is used, according to Brodersen et al. (2015). This model calculates a counterfactual to estimate suicide rates if the pandemic had not occurred.

2.2.1 Main Elements

The Bayesian structural model of time series uses two main equations to model the historical series of suicide rates and estimate the causal impact of the pandemic. The first of these is the observation equation, which relates the observed indices to the latent states of the series, allowing the model to capture the observed variability over time:

$$y_t = Z_t \alpha + \epsilon_t, \epsilon_t \sim N(0, \sigma^2) \quad (01)$$

In this equation, it represents the observed suicide rate over time, while it is the vector that connects observations to the internal states of the system. The state vector represents latent variables, providing a framework that allows you to identify patterns over time. The term, which follows a normal distribution, represents the observation error, capturing possible discrepancies between the observed and predicted values, adjusting the accuracy of subsequent projections. The observation equation thus links the actual data to the latent structure of the model, absorbing the observed fluctuations in suicide rates. $y_t = Z_t \alpha_t + \epsilon_t, \epsilon_t \sim N(0, \sigma^2)$

The second main equation, the equation of state, describes how latent states evolve over time, enabling the model to capture pattern changes and respond to external shocks, such as the impact of the pandemic: α_t

$$\alpha_{t+1} = T_t \alpha_t + R_t \eta_t, \eta_t \sim N(0, Q_t) \quad (02)$$

In this expression, it is the transition matrix that relates the current state to the future state, essential to model the continuity of the time series. The matrix controls the influence of the error term, normally distributed as , which represents variations not directly explained by the model. This term adjusts the model to unforeseen changes or external events, such as social isolation and other restrictions imposed by the pandemic. The equation of state, therefore, allows the model to capture the internal dynamics and adapt to variations in suicide rates, reflecting possible impacts of the social and public health context. $T_t \alpha_t + R_t \eta_t \sim N(0, Q_t)$

These two equations, when applied together, allow the Bayesian structural model of time series to accurately project counterfactual scenarios, serving as a basis for inferring the causal impact of the pandemic on suicide rates.

2.2.2 Model Components

The model includes specific components to capture local trends and possible seasonalities in suicide rate data. The trend is modeled by a random walk process, described by the following equations:

$$\mu_{t+1} = \mu_t + \delta_t + \eta_{\mu,t} \quad (03)$$

$$\delta_{t+1} = \delta_t + \eta_{\delta,t} \quad (04)$$

Where is the value of the trend in time and represents the slope or rate of change of the trend. These components allow the model to adjust for natural fluctuations in suicide rates over

time. Seasonality is also incorporated into the model, representing the periodic variations in suicide rates that can occur in certain months or times of the year. The inclusion of these components allows the model to provide more accurate projections over time. $\mu_t \delta_t$

2.2.3 Counterfactual Estimation

To measure the impact of the pandemic, the model calculates a counterfactual estimate of suicide rates, representing what would have been expected if the pandemic had not occurred. From the date of the beginning of the pandemic, the model uses the parameters and the structure established with the historical data to project the counterfactual series. The difference between the observed values and the counterfactual projection during the pandemic period represents the causal impact. For each point in the pandemic period, the causal impact is calculated as follows: Δy_t

$$\Delta y_t = y_{observado,t} - y_{contrafactual,t} \quad (05)$$

where $y_{observado,t}$ is the actual suicide rate in time, and $y_{contrafactual,t}$ is the value projected by the model in the absence of the pandemic. This difference makes it possible to estimate the specific impact of the pandemic on suicide rates.

To calculate the cumulative impact over the pandemic period, the differences are added: Δy_t

$$\text{Total impact} = \sum \Delta y_t \quad (06)$$

The model also calculates credibility intervals for the counterfactual projection, offering a measure of the uncertainty associated with the estimate and strengthening confidence in the results.

2.2.4 Data Source

The data used in this research were obtained through the National Information System for Public Security, Prisons, Traceability of Weapons and Ammunition, Genetic Material, Fingerprints and Drugs (SINESP), an agency linked to the Ministry of Justice and Public Security. The time series covers the period from January 2015 to April 2023, with data organized monthly. The variable analyzed in this research is the number of suicide victims.

The year 2015 was chosen as the starting point, as it represents the oldest data available, allowing a broad and detailed analysis of trends over the years, in addition to enabling the evaluation of the impact of changes in public safety and mental health indicators. The period ends in April 2023, the month that marks the official end of the COVID-19 pandemic, according to the WHO decree, allowing the end of the analysis along with the end of the pandemic.

3 RESULTS AND DISCUSSIONS

3.1 DYNAMICS OF SUICIDES IN BRAZIL AND REGIONS

The analysis of monthly suicide records in Brazil between January 2015 and March 2023 shows a growing trend, with a significant increase from 2020 onwards.

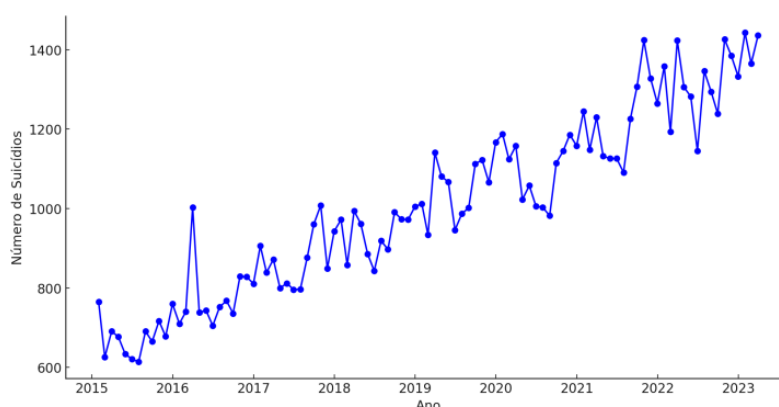
Between 2015 and 2019, the monthly average was approximately 864.55 cases, while between 2020 and 2023, this average rose to 1,224.82 cases per month, representing a growth of 41.67% in the period. This increase suggests the influence of the COVID-19 pandemic on the intensification of risk factors for suicide, such as social isolation, financial difficulties, and restrictions on access to mental health services.

The annual growth rate between 2015 and 2019 ranged between 7.76% and 15.05%, while between 2020 and 2023 the annual growth was more moderate, ranging between 7.39% and 11.43%. In terms of monthly growth, the average number of suicides increased by 41.67%, from 864.55 to 1,224.82 cases, indicating a substantial change in the number of victims over the period analyzed.

Although the analysis of the data shows an increasing trend, there is no significant volatility in records after 2020, which suggests that, after the initial peak of the health crisis, factors associated with the pandemic, such as social isolation and economic difficulties, continued to impact suicide rates almost constantly until the end of the pandemic. Figure 1 illustrates this escalation, allowing us to visualize the intensification of suicide records over the years.

Figure 1

Monthly evolution of the total number of suicides in Brazil (2015-2023)



Source: Prepared by the author based on data from the National Public Security Information System (SINESP), 2024

To identify evidence of the magnitude of the impact of the COVID-19 pandemic on suicides, Student's t-test was applied to compare the means of the pre-pandemic (2015-2019) and post-pandemic (2020-2023) periods.

The result of the test indicated a statistically significant difference between the means of suicides in these two periods. The extremely low p-value ($< 2.2 \times 10^{-16}$) and the t-statistic of -11.696 suggest that the average number of suicides in the post-pandemic period was considerably higher compared to the pre-pandemic period. The 95% confidence interval for the difference between the means was from -414.75 to -294.42, confirming the increase in suicide rates after the beginning of the pandemic (Table 2).

In addition, the results of the t-test reveal that the observed increase was not an isolated phenomenon, but rather a substantial change in suicide rates in Brazil. The impact of the pandemic seems to have created a plateau in the records, with no return to previous levels. The significant difference between the averages reinforces the hypothesis that the pandemic had a substantial and lasting effect on suicide rates.

Table 1

Results of the Student's t-test for comparison of means before and after the pandemic.

Parameter	Value
Statistics t	-11,696
Degrees of Freedom (df)	97
p-value	$< 2.2 \times 10^{-16}$
95% confidence interval	-414.75 to -294.42
Average "before the pandemic"	873,95
Average "after the pandemic"	1.228,54

Source: Survey results.

While the growth in the total number of suicides is evident, the regional analysis reveals significant disparities. The Southeast, as it concentrates the largest population, registers the highest absolute numbers, but, when considering the rate per 100 thousand inhabitants, the South stands out as the most affected region. In 2015, the suicide rate in the South was 8.0 per 100,000 inhabitants, while the national average was 4.7. In 2023, the rate in the South rose to 10.9, while the national average reached 6.8. The Central-West also showed a significant growth, changing from 4.6 to 9.0 per 100 thousand inhabitants in the same period. These data show that the increase in suicides does not occur homogeneously in the country, reflecting possible socioeconomic, cultural, and access to mental health services differences between regions.

Table 3

Suicide rates per 100 thousand inhabitants in Brazil and regions (2015-2023)

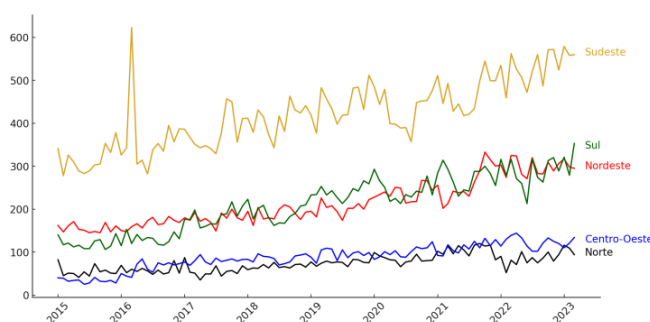
Year	Brazil	North	Northeast	Midwest	Southeast	South
2015	4,7	3,8	4,0	4,6	4,6	8,0
2016	5,1	4,0	4,3	4,9	5,1	8,6
2017	5,3	3,8	4,4	6,1	5,2	7,4
2018	5,5	4,5	4,1	6,4	5,7	7,6
2019	6,3	5,1	4,9	7,1	6,1	9,6
2020	6,3	5,5	5,1	7,3	5,9	9,6
2021	7,0	6,9	5,5	8,1	6,4	10,8
2022	7,5	6,0	6,2	8,8	7,1	11,2
2023	7,8	7,0	6,8	9,0	7,3	10,9

Source: Prepared by the author based on data from the National Public Security Information System (SINESP), 2024.

Figure 2 illustrates the evolution of the absolute number of suicides by region, while Table 2 details the variation in rates per 100 thousand inhabitants over the years. These differences may be associated with regional factors, such as cultural, socioeconomic, and environmental aspects. Studies suggest that in the South, the higher prevalence of diagnosed psychiatric disorders, lower exposure to sunlight, and differences in social structure may contribute to higher suicide rates.

Figure 2

Monthly number of suicides by region of the country



Source: Prepared by the author based on data from the National Public Security Information System (SINESP), 2024.

In addition, the COVID-19 pandemic has had a notable impact on suicide rates in all regions of Brazil. Table 8 shows the results of suicides by region before and during the pandemic, revealing significant increases in all areas of the country.

Table 3

Annual average of suicides by region before and during the pandemic

Region	Before the pandemic	After the pandemic
North	62,95	91,43
Northeast	179,68	270,16
Midwest	71,97	113,73
Southeast	384,15	483,00
South	175,69	271,03

Source: Survey results.

These increases are even more significant when we look at the results of the Student's t-tests to compare the means before and during the pandemic, presented in Table 5. In all regions, the p-values were extremely low, indicating that the differences in the means of suicides did not occur by chance, but reflect the profound emotional impact of the health crisis.

Table 5

Student's t-test results for comparison of means before and during the pandemic by region

Region	Statistics t	p-value	95% confidence interval
North	-9,3995	$2,657 \times 10^{-15}$	-34.49 to -22.47
Northeast	-15,169	$< 2.2 \times 10^{-16}$	-102.32 to -78.65
Midwest	-9,7025	$5,886 \times 10^{-16}$	-50.30 to -33.22
Southeast	-7,4008	$4,921 \times 10^{-11}$	-125.37 to -72.34
South	-10,181	$< 2.2 \times 10^{-16}$	-113.92 to -76.75

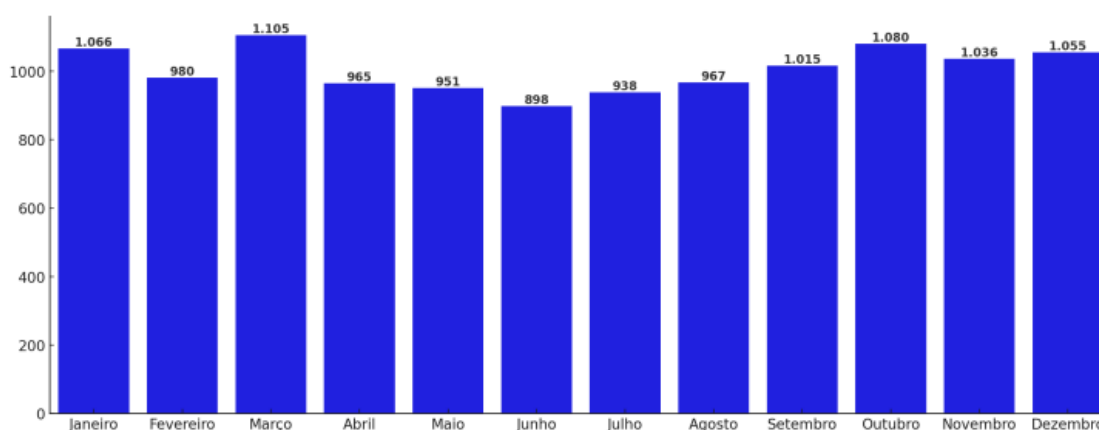
Source: Survey results.

These data indicate that the pandemic has had a significant negative impact on the mental health of the population, with a generalized increase in suicide rates, especially in regions with higher rates before the pandemic, such as the Southeast. The increase was also notable in areas with lower rates, such as the North. Factors such as social isolation, economic uncertainty, and the overload of health systems have likely exacerbated this effect, reinforcing the need for psychological and mental health support measures in times of crisis.

In addition to the regional differences, it is possible to observe, as shown in Figure 03, that over the years, some months have relatively higher numbers of suicides, such as March, September and December, while February and June register the lowest rates. However, there is no clear or consistent seasonality in the data. These monthly variations do not follow a fixed pattern and therefore cannot be attributed to specific seasonal factors.

Figure 3

Monthly variations in suicide records in Brazil from 2015 to 2023



Source: Prepared by the author based on data from the National Public Security Information System (SINESP), 2024.

Analysis by gender also reveals significant differences. Between 2015 and 2023, men accounted for the majority of cases, but the growth among women was proportionally higher.

The monthly average for men rose from 658 to 956 cases (+43%), while the female average went from 174 to 267 cases (+56%). This proportionally higher increase among women suggests that recent external factors, such as the COVID-19 pandemic, may have impacted genders differently.

Although the absolute number of suicides among men is still higher, women have shown a more significant growth in the last decade. This phenomenon may be related to changes in social roles, greater exposure to psychological stress, and difficulties in accessing mental health services.

To test this hypothesis, a t-Student's mean test was performed to compare the numbers of suicides before and after the pandemic for both genders. The result for men indicated a significant difference between the means, with a t-value of -11.257, degrees of freedom (df) equal to 97 and a p-value of less than 2.2×10^{-16} .

The averages for male suicides were 657.42 (pre-pandemic) and 956.86 (during), with a 95% confidence interval between -352.239 and -246.652. This result confirms that the difference in the means is not equal to zero, indicating that there was a significant change in the number of suicides among men during this period.

For women, the Student's t-test also showed a significant difference in the means before and after the pandemic. The t-value was -11.524, with 97 degrees of freedom and a p-value lower than 2.2×10^{-16} . The averages observed were 173.90 (pre-pandemic) and 266.68 (during), with a 95% confidence interval between -108.75 and -76.79. This result suggests a substantial difference in female suicides before and after the beginning of the pandemic, with a more significant increase compared to men. Below, we present the table with the results of the Student's t-test for the comparison of the means before and after the pandemic for males and females.

Table 5

Student's t-test results for comparison of means before and during the pandemic by gender

Gender	Statistics t	p-value	95% confidence interval
Men	-11,257	$< 2.2 \times 10^{-16}$	-352,239 to -246,652
Women	-11,524	$< 2.2 \times 10^{-16}$	-108.75 to -76.79

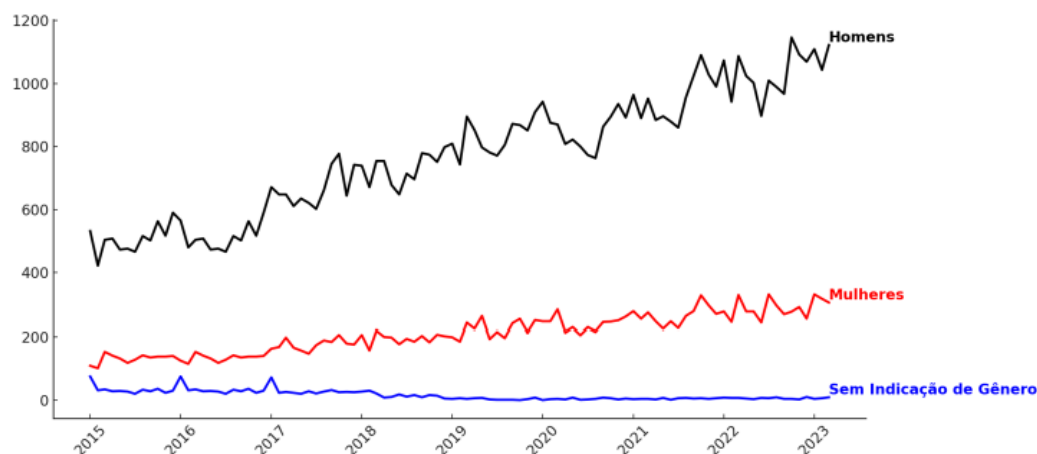
Source: Survey results.

Another relevant point is that suicide records without gender information remained low throughout the period analyzed, but from 2020 onwards there was a slight increase in these cases. This may be related to changes in the way data is collected or the rise of non-traditional gender identities in registries.

In addition to general trends, monthly fluctuations in suicide records also showed differences between genders. Among men, the months of March, July and September recorded the highest numbers of cases, while among women, the peaks occurred in December and April. These patterns may be related to distinct emotional and social factors, such as economic crises and family events, which impact each group differently.

Figure 5

Monthly evolution of the number of suicides by gender (2015-2023)



Source: Prepared by the author based on data from the National Public Security Information System (SINESP), 2024.

3.2 EFFECTS OF COVID-19 ON SUICIDES IN BRAZIL

The COVID-19 pandemic has had a profound and significant impact on the increase in the number of suicides in Brazil, with significant growth in rates over the past few years. When comparing the observed data with the counterfactual forecasts, which indicate what would have happened without the pandemic, the direct and causal effect of the health crisis on the mental health of the Brazilian population becomes evident, reflected in a substantial increase in suicide rates.

Before the pandemic, the monthly average of suicides was 888, but that number rose to 1,230 after the crisis began, resulting in an additional 342 suicides per month. This difference is highly significant, with a confidence interval of 95%, proving the dramatic impact of the pandemic on the mental health of Brazilians.

Between 2020 and 2023, the total number of suicides observed was 44,298, compared to a counterfactual forecast of 31,970 suicides in the same period. The cumulative increase of 12,328 additional suicides represents a 39% growth in the total number of suicides in Brazil, highlighting not only the severity of the pandemic's effect, but also the urgent need for public policies to address mental health challenges in the country.

Table 7

Causal effects of the COVID-19 pandemic on suicide rates in Brazil

Metric	Average	Cumulative
Observed	1.230	44.298
Counterfactual	888 (33)	31.970 (1.176)
Absolute effect	342 (33)	12.328 (1.176)
Relative effect	39% (5,1%)	39% (5,1%)
p-value	0,001	

Source: Survey results.

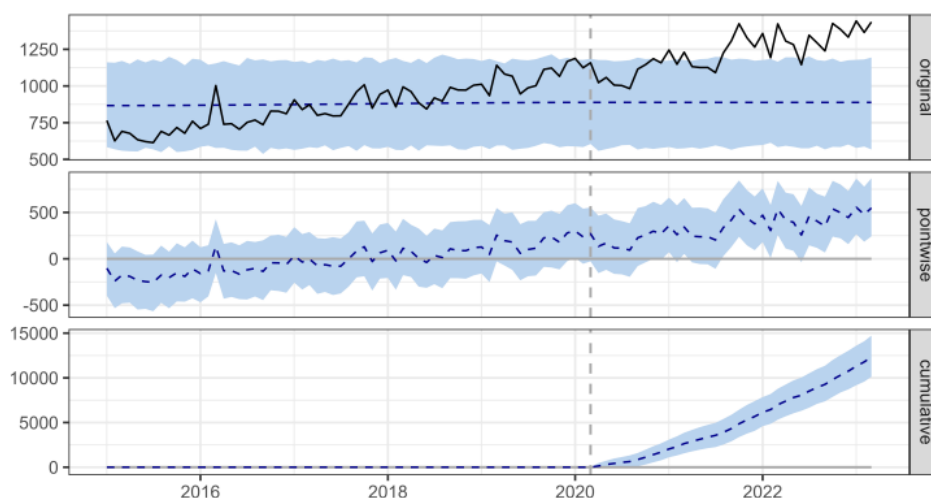
Figure 6 provides a clear and detailed representation of the significant impact of the COVID-19 pandemic on suicide rates in Brazil. The top graph, called the *original*, shows the actual data of suicides observed over time, with the black line representing the actual numbers. The middle graph, called *pointwise*, focuses on what would have happened without the pandemic, highlighting monthly predictions of the number of suicides without the effect of the crisis. The lower graph, *cumulative*, shows the accumulated difference over time between actual suicides and counterfactual predictions, allowing us to visualize the total impact of the pandemic.

From 2020, when the pandemic began, it is possible to observe a growing disparity between the two lines, showing a significant increase in suicides, especially after the beginning of the pandemic. This increase is accentuated as the months progress, with the black line showing a continuous increase in both monthly values and cumulative total, compared to the predicted rates. The difference between the actual values and the counterfactual forecasts underlines the direct and substantial impact of the pandemic on the mental health of the Brazilian population.

These graphs show the persistent and growing impact of the pandemic on suicide rates in Brazil, both in monthly and cumulative terms. The observed pattern reinforces the urgency of public policies focused on suicide prevention and care for the population's mental health.

Figure 6

Counterfactual prediction and actual number of suicides in Brazil during the COVID-19 pandemic



Source: Survey results.

Bayesian analysis revealed that the probability of the observed increase being the result of random fluctuations is extremely low. The p-value was 0.001, indicating high statistical significance, and the subsequent probability that the pandemic had a direct causal effect on the increase in suicides was 99.9%. These figures indicate that the increase in the number of suicides in Brazil is not a mere coincidence, but rather a significant consequence of the pandemic, reinforcing the hypothesis that factors related to the health crisis, such as social isolation, economic instability, and increased psychological stress, played a crucial role in this phenomenon. This is an important finding for the formulation of public policies focused on mental health in Brazil, especially during periods of crisis.

These results are in line with studies carried out in Brazil, such as those by Gunnell et al. (2020) and Tanaka & Okamoto (2021), which point out that large-scale events, such as pandemics and economic crises, have negative and long-lasting effects on the mental health of populations, significantly increasing the risk of suicides.

In the Brazilian context, the psychosocial impact of the pandemic has been particularly accentuated due to social inequality, the collapse of the health system, and economic insecurity. These factors, combined with the disruption of social support networks, are crucial elements that contributed to the increase in suicides in Brazil during the pandemic.

The Social Deprivation Theory, which suggests that social isolation and the absence of emotional support networks exacerbate mental health problems and increase vulnerability to suicidal behaviors, can be applied to the Brazilian context. During the pandemic, many people

in Brazil experienced emotional loneliness and social loneliness, both aspects of social deprivation. Emotional loneliness, referring to the absence of intimate bonds, and social loneliness, due to the lack of a broad support network, are critical factors that contribute to psychological suffering.

Weiss's Theory of Social Deprivation (1973) states that, in contexts of social deprivation, the increase in feelings of hopelessness and helplessness can be a decisive factor for the increase in suicides. The increase in isolation and the decrease in physical interactions during the pandemic may have amplified these effects, particularly in vulnerable populations in Brazil, such as the elderly, people with preexisting mental health problems, and those in situations of social vulnerability.

In Brazil, data from 2023 indicate that the number of suicides continues to be a growing problem, with more than 16,000 cases recorded this year alone. These figures put the country in an alarming situation, in line with the results of our analysis, reinforcing the need for a more robust approach to mental health care.

3.3 REGIONAL EFFECTS OF COVID-19 ON SUICIDES IN BRAZIL

The analysis of the impact of the COVID-19 pandemic on suicides reveals a significant increase in all five regions of Brazil, reinforcing the hypothesis that the health crisis had a direct effect on the mental health of the population. Comparing the observed data with the counterfactual forecasts, we found a significant increase in suicides in absolute and relative terms in all regions, although with variations in the magnitude of the impact.

In the North Region, monthly suicides averaged 92 cases after the beginning of the pandemic, while the counterfactual forecast was 64 cases per month. This represents an average absolute increase of 27 monthly suicides, corresponding to a growth of 42%. The cumulative impact between 2020 and 2023 resulted in 981 additional suicides, bringing the total observed to 3,296 cases. The vulnerability of the North Region may be associated with limited access to mental health services, socioeconomic difficulties, and geographic isolation, factors that may have exacerbated the impact of the pandemic on the psychological health of the population.

The Northeast Region showed an even more significant increase, with a monthly average of 271 suicides, while the counterfactual forecast was 182 cases per month. The average increase of 89 monthly suicides resulted in a relative increase of 49%. In the cumulative period between 2020 and 2023, 3,208 additional suicides were recorded, bringing the total to 9,756 cases. The region was already facing structural challenges, such as high rates of inequality and

poor access to mental health services, which may have amplified the pandemic's impact on suicides.

In the Midwest, the percentage impact was even greater, with an average increase of 41 monthly suicides, raising the average from 73 to 114 suicides per month. The relative growth was 56%, resulting in an increase of 1,464 suicides in the accumulated period, bringing the total observed to 4,107 cases. The combination of rapid urban growth, economic pressure, and limited specialized mental health services may have contributed to this substantial increase.

The Southeast Region, despite presenting the smallest percentage increase, had the greatest absolute impact in total numbers. The monthly average rose from 388 to 483 suicides per month, an absolute increase of 95 monthly suicides (+25%). In total, there were 3,410 additional suicides in the period analyzed, bringing the total number of cases to 17,392. The region, which concentrates the largest urban centers in the country, faced challenges such as increased economic instability, social isolation, and overload on health services, factors that may have contributed to this significant increase.

The South Region had one of the highest percentage impacts, with a 51% growth in suicides. The monthly average rose from 180 to 272 suicides, an absolute increase of 91 monthly suicides. In the accumulated between 2020 and 2023, there were 3,293 additional suicides, bringing the total observed to 9,777 cases. Historically, the South already had higher suicide rates than other regions of Brazil, and the pandemic may have intensified this scenario, amplifying the challenges related to mental health.

The table below summarizes the causal effects of the pandemic on suicides in each region, presenting the observed values, counterfactual predictions, and absolute and relative effects.

Table 8

Causal effects of the COVID-19 pandemic on suicide rates by region

Region	Observed Average	Counterfactual Average	Relative Effect
North	92	64	+42%
Northeast	271	182	+49%
Midwest	114	73	+56%
Southeast	483	388	+25%
South	272	180	+51%

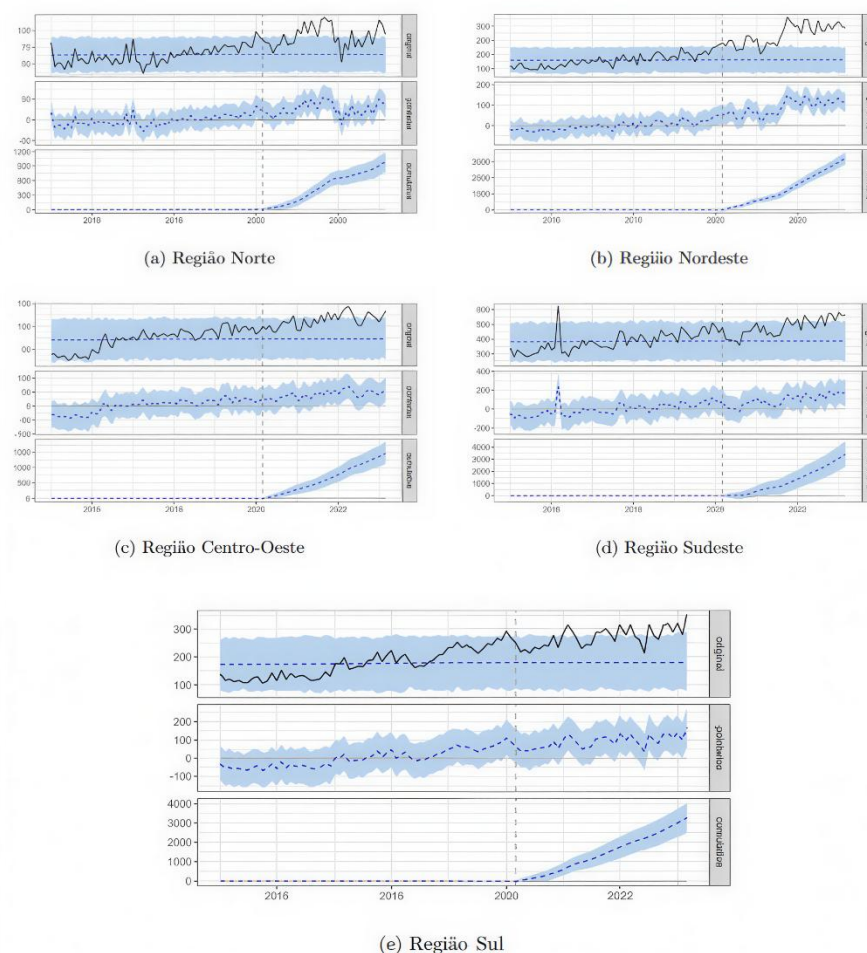
Source: Survey results.

Figure 7 illustrates the evolution of suicide rates in the various regions of Brazil between 2015 and 2023, highlighting the significant impact of the COVID-19 pandemic. The graph compares the observed values with counterfactual forecasts, revealing a significant growth in

suicides in all regions of the country after the beginning of the pandemic. The growing disparity between actual data and counterfactual estimates underlines the profound and widespread effect of the health crisis on the mental health of the Brazilian population.

Figure 7

Causal effect of the COVID-19 pandemic on the number of suicides by region in Brazil



Source: Survey Results.

4 CONCLUSIONS

The present research aimed to analyze the impact of the COVID-19 pandemic on suicide rates in Brazil, considering both the general effects and regional variations in the period from 2020 to 2023. From a robust statistical analysis, based on counterfactual predictions, it was possible to demonstrate that the pandemic generated a significant increase in the number of suicides. The findings reinforce the hypothesis that factors such as social isolation, economic instability, and increased psychological stress severely affected the mental health of the Brazilian population.

The quantitative analysis revealed a substantial increase in suicides throughout Brazil, with an average growth of 39% compared to what was expected without the pandemic. This impact was observed both at the national and regional levels, with some areas experiencing more significant variations. The Midwest region, for example, showed the highest relative growth, with a 57% increase in suicides, while the Southeast region, although it registered the highest absolute number of cases, had a proportionally smaller growth. These regional disparities highlight the influence of local factors, such as access to mental health services, socioeconomic inequalities, and available social support.

In addition to the global and regional impact, the study identified relevant seasonal patterns in the distribution of suicides throughout the year. The analysis showed that certain months, such as March, September and December, had higher incidences, while February and June recorded the lowest numbers. The identification of these seasonal variations allows the formulation of more effective public policies, such as the reinforcement of awareness campaigns and the expansion of psychological support in periods of higher incidence. Measures such as strengthening social support networks and targeted preventive strategies can contribute significantly to reducing cases in the most critical months.

Despite the contributions of the research, some limitations must be acknowledged. The use of secondary data may be subject to inaccuracies or underreporting, especially in more remote regions, which may have affected the accuracy of the estimates. In addition, the analysis did not include variables such as comorbidities or the impact of specific public policies adopted during the pandemic, which could provide a more complete picture of the factors that influenced suicides in the period analyzed. Future research can address these gaps by incorporating more detailed variables and a more in-depth longitudinal approach.

One detail cannot be forgotten, in psychology we cannot speak of causality in the economic/statistical sense. Although the method identifies causal relationships, it is not possible to state in a peremptory way that the pandemic alone causes suicide. However, there is evidence of influence.

The study also paves the way for further investigations into the impact of global crises on mental health, especially in contexts such as Brazil, where social inequalities amplify the negative effects of these crises. Future studies could explore in more detail the relationship between social vulnerability and the increase in suicides during the pandemic, as well as evaluate the effectiveness of psychological support programs implemented during these periods. Understanding these gaps will allow the development of more assertive and effective policies to cope with suicide, both in times of normality and in times of crisis.

Finally, it is necessary for the Brazilian authorities to implement effective psychological support programs, especially for populations in vulnerable situations. The pandemic has highlighted gaps in mental health support that need to be addressed in the long term. The significant increase in suicides reinforces the need to rebuild social support networks and expand public policies aimed at mental health. Only with concrete and continuous actions will it be possible to mitigate the impacts of future crises and ensure the psychological well-being of the Brazilian population.

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**PROPERTY VIOLENCE AGAINST WOMEN IN MANAUS, AMAZONAS:
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ABSTRACT

Domestic and family violence against women represents one of the most significant social and legal issues in contemporary society, directly affecting women's dignity, autonomy, and fundamental rights. Among the different forms of violence established under Brazilian legislation, property violence stands out due to its ability to restrict victims' economic independence and perpetuate abusive relationships marked by financial control and economic dependence. In this context, the present study aimed to analyze public policies for the prevention and confrontation of domestic and family violence against women, with emphasis on property violence in the city of Manaus, Amazonas. The research is characterized as a literature review, with a qualitative nature and a descriptive and analytical approach, developed through scientific articles, institutional documents, and technical reports published within the last five years. The results revealed that property violence remains socially and institutionally invisible in several contexts, making its identification and confrontation by public agencies more difficult. It was also observed that factors such as social vulnerability, economic dependence, and structural limitations within the protection

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network contribute to increasing the difficulties faced by women victims of domestic violence in the Amazon region. It is concluded that strengthening preventive public policies, intersectoral state action, and mechanisms aimed at women's financial autonomy constitutes an essential measure for reducing property violence and ensuring the effective protection of women's rights.

Keywords: Amazon. Domestic Violence. Property Violence. Public Policies. Women.

RESUMO

A violência doméstica e familiar contra a mulher representa uma das mais relevantes problemáticas sociais e jurídicas da contemporaneidade, atingindo diretamente a dignidade, a autonomia e os direitos fundamentais femininos. Entre as diferentes formas de violência previstas na legislação brasileira, a violência patrimonial destaca-se pela sua capacidade de restringir a independência econômica da vítima e perpetuar relações abusivas marcadas pelo controle financeiro e pela dependência econômica. Nesse contexto, o presente estudo teve como objetivo analisar as políticas públicas de prevenção e enfrentamento à violência doméstica e familiar contra a mulher, com ênfase na violência patrimonial no município de Manaus, Amazonas. A pesquisa caracteriza-se como revisão de literatura, de natureza qualitativa e abordagem descritiva e analítica, desenvolvida a partir de artigos científicos, documentos institucionais e relatórios técnicos publicados nos últimos cinco anos. Os resultados evidenciaram que a violência patrimonial permanece invisibilizada em diversos contextos sociais e institucionais, dificultando sua identificação e enfrentamento pelos órgãos públicos. Observou-se ainda que fatores como vulnerabilidade social, dependência econômica e limitações estruturais da rede de proteção contribuem para ampliação das dificuldades enfrentadas pelas mulheres vítimas de violência doméstica no contexto amazônico. Conclui-se que o fortalecimento das políticas públicas preventivas, da atuação intersectorial do Estado e dos mecanismos de autonomia financeira feminina constitui medida essencial para redução da violência patrimonial e garantia efetiva dos direitos das mulheres.

Palavras-chave: Amazônia. Políticas Públicas. Violência Doméstica. Violência Patrimonial. Mulheres

RESUMEN

La violencia doméstica y familiar contra la mujer representa una de las problemáticas sociales y jurídicas más relevantes de la contemporaneidad, afectando directamente la dignidad, la autonomía y los derechos fundamentales femeninos. Entre las diferentes formas de violencia previstas en la legislación brasileña, la violencia patrimonial se destaca por su capacidad de restringir la independencia económica de la víctima y perpetuar relaciones abusivas marcadas por el control financiero y la dependencia económica. En este contexto, el presente estudio tuvo como objetivo analizar las políticas públicas de prevención y enfrentamiento de la violencia doméstica y familiar contra la mujer, con énfasis en la violencia patrimonial en la ciudad de Manaus, Amazonas. La investigación se caracteriza como una revisión de literatura, de naturaleza cualitativa y enfoque descriptivo y analítico, desarrollada a partir de artículos científicos, documentos institucionales e informes técnicos publicados en los últimos cinco años. Los resultados evidenciaron que la violencia patrimonial permanece invisibilizada en diversos contextos sociales e institucionales, dificultando su identificación y enfrentamiento por parte de los organismos públicos. También se observó que factores como vulnerabilidad social, dependencia económica y limitaciones estructurales de la red de protección contribuyen al aumento de las dificultades enfrentadas por las mujeres víctimas de violencia doméstica en el contexto amazónico. Se concluye que el

fortalecimiento de las políticas públicas preventivas, de la actuación intersectorial del Estado y de los mecanismos de autonomía financiera femenina constituye una medida esencial para la reducción de la violencia patrimonial y la garantía efectiva de los derechos de las mujeres.

Palabras clave: Amazonia. Mujeres. Políticas Públicas. Violencia Doméstica. Violencia Patrimonial.

1 INTRODUCTION

Domestic and family violence against women remains one of the most serious human rights violations in contemporary society, affecting women from different social classes, age groups and cultural contexts. Among the various manifestations of this violence, property violence stands out for its ability to directly compromise the victim's economic autonomy and financial freedom, often remaining invisible both in the social and institutional spheres. In this scenario, the Maria da Penha Law represented an important legal advance by recognizing property violence as one of the forms of domestic violence, expanding the legal mechanisms for the protection of women in vulnerable situations.

According to Campos (2024), gender-based violence has structural roots related to historical inequalities between men and women, going beyond the limited understanding of violence as a simple interpersonal conflict. This perspective demonstrates that practices of economic control, retention of assets and financial restriction are instruments for maintaining male domination in family relationships. In this way, property violence is not restricted to the material losses suffered by the victim, but also reaches their psychological, emotional and social autonomy.

The Brazilian reality shows that property violence still faces high rates of underreporting and difficulties in identification by the agencies responsible for protecting victims. Sousa et al. (2024) highlight that the lack of standardization of institutional records and the social invisibility of this type of violence make it difficult to formulate more efficient preventive public policies. In addition, many women do not recognize certain abusive practices as forms of domestic violence, especially when related to the financial control exercised by the aggressor within the family environment.

In the Amazonian context, the challenges become even more complex due to territorial inequalities, structural limitations of public services and difficulties in accessing the protection network. The Igarapé Institute (2024) shows that the Legal Amazon has worrying rates of violence against women, associated with social vulnerability, institutional fragility, and difficulties in accessing reporting and reception mechanisms. In Manaus, such factors contribute to the expansion of the obstacles faced by victims of domestic and property violence, requiring the strengthening of public policies for prevention and protection.

Property violence has profound impacts on women's lives, compromising their financial independence and making it difficult to break the cycle of violence. Quirino et al. (2026) state that practices such as retention of documents, destruction of personal property, control of salaries, and impediment of access to financial resources function as mechanisms of

submission and control within abusive relationships. This reality highlights the need to understand property violence not only from a legal perspective, but also from a social, economic and institutional perspective.

In view of this scenario, it is relevant to investigate how public policies to prevent and combat domestic and family violence against women have acted to protect victims of property violence in the municipality of Manaus, Amazonas. The research seeks to understand the main challenges faced by the institutional protection network, as well as to analyze the existing preventive mechanisms and their effectiveness in the face of the regional specificities of the Amazon.

The discussion on domestic and family violence against women requires a multidisciplinary approach, considering the legal, social, economic, and institutional impacts produced by the different forms of violence provided for in Brazilian legislation. In this sense, Costa et al. (2024) highlight that effective public policies must act in an integrated manner, articulating preventive, protective, and assistance actions capable of reducing the vulnerability of victims and promoting greater effectiveness in confronting gender violence. Such an understanding reinforces the importance of joint action between public security, social assistance, health and the Judiciary.

In the state of Amazonas, the expansion of public policies aimed at the protection of women has sought to strengthen institutional mechanisms for the prevention and reception of victims of domestic violence. The Amazonas Public Security Secretariat (2025) points out that the fight against violence against women depends on the integration between different government sectors, especially due to the territorial and social particularities present in the Amazon region. However, challenges remain related to the coverage of specialized services and the effective implementation of preventive actions in socially vulnerable areas.

The presence of specialized agencies also plays a fundamental role in the protection of women in situations of violence. Gomes et al. (2025) observe that pro-women institutions contribute significantly to strengthening the reception network, access to justice and referral of victims to social and psychological assistance services. In cities marked by social inequalities, such as Manaus, such structures become essential to reduce female vulnerability and expand institutional protection in the face of multiple forms of domestic violence.

Another relevant aspect refers to the impacts of domestic violence on the physical and emotional health of victims. Alcantara et al. (2024) argue that comprehensive care for women in situations of violence should consider the psychological, social, and economic effects produced by abusive practices. According to the authors, property violence often compromises

the financial and emotional stability of women, making it difficult to break the abusive relationship and increasing the damage resulting from domestic violence.

In addition, recent social effects have intensified challenges related to access to justice for women victims of domestic violence. Paiva et al. (2023) demonstrate that situations of social and economic crisis increase women's financial dependence and make it difficult to activate institutional protection mechanisms. This scenario highlights the need for continuous strengthening of preventive public policies, especially in regions marked by socioeconomic vulnerability and structural limitations of public services.

Thus, the present research is justified by the need to broaden academic discussions on patrimonial violence against women in the Amazonian context, considering the social and institutional specificities of Manaus, Amazonas. The study aims to analyze public policies to prevent and combat domestic and family violence against women, with an emphasis on property violence, seeking to understand the main challenges in the protection network and the effectiveness of institutional strategies aimed at guaranteeing women's rights.

2 THEORETICAL FRAMEWORK

Domestic and family violence against women represents one of the most persistent human rights violations in contemporary society, manifesting itself through physical, psychological, sexual, moral and patrimonial aggression. In the Brazilian context, the expansion of the legal and institutional debate about this violence has consolidated the need to understand the problem in a multidimensional way, especially in regions marked by social inequalities and structural difficulties in accessing public policies, as occurs in Manaus, Amazonas. In this sense, Campos (2024) highlights that gender-based violence cannot be interpreted only as interpersonal conflict, but as a reflection of historical relations of power and female subordination present in social structures.

The Maria da Penha Law significantly expanded the legal concept of domestic violence by recognizing different forms of aggression against women, including property violence. According to Campos (2024), the conceptual dispute around gender violence demonstrates that the practices of economic and financial control exercised against women are strongly related to the maintenance of the victim's emotional and material dependence on the aggressor. Thus, patrimonial violence goes beyond the simple retention of assets, involving systematic mechanisms of domination that compromise autonomy, dignity and women's freedom.

The discussion about property violence gains relevance in the face of the social invisibility of this type of violence. Quirino et al. (2026) point out that most victims do not even recognize

certain abusive practices as violence, especially when related to wage control, retention of documents, destruction of personal objects or impediment of access to financial resources. According to the authors, recent literature shows that patrimonial violence usually occurs in association with other forms of domestic violence, functioning as an instrument for maintaining the cycle of submission of women within the family environment.

When analyzing the structure of public policies to combat violence against women, Costa et al. (2024) state that the effectiveness of government actions depends on the integration between prevention, protection, assistance, and accountability of the aggressor. The authors argue that fragmented policies tend to produce low capacity for social intervention, especially in contexts of economic vulnerability. Thus, the evaluation of public policies requires observation not only of the formal existence of institutional programs, but also of their effective capacity to reach women at risk.

The Amazonian reality presents particularities that intensify the challenges of protecting women victims of domestic violence. The Igarapé Institute (2024) shows that the states of the Legal Amazon have high rates of violence against women, associated with territorial inequality, structural limitations of public services, and difficulties in accessing protection agencies. The study shows that municipalities with a smaller state presence face greater obstacles to the implementation of preventive policies, a factor that has a direct impact on the underreporting of cases of property violence.

In the specific case of Amazonas, the State Plan for the Prevention and Confrontation of Violence Against Women establishes strategies aimed at expanding the protection network, institutional strengthening and promotion of educational actions aimed at preventing domestic violence. The Amazonas Public Security Secretariat (2025) emphasizes that confronting violence against women requires intersectoral articulation between public security, social assistance, health, and the Judiciary, seeking to ensure full protection for victims. This perspective demonstrates that the fight against property violence requires coordinated action between different public agencies.

The importance of specialized institutions is also emphasized by Gomes et al. (2025), when analyzing the relationship between women's protection agencies and the reduction of violence rates in Brazil. According to the authors, locations that have specific institutional structures, such as specialized police stations, shelter centers and legal assistance programs, tend to have better conditions for coping with domestic violence. This finding has special relevance for Manaus, considering the need for continuous strengthening of the women's protection network in the face of the growth of lawsuits related to family violence.

In the context of victim care, Alcantara et al. (2024) argue that comprehensive care for women in situations of violence should consider not only the physical consequences of aggression, but also the emotional, social, and economic impacts resulting from abusive practices. The authors state that property violence often produces prolonged effects on women's financial autonomy, hindering their ability to break the cycle of domestic violence. Thus, preventive public policies need to incorporate strategies for economic strengthening and social inclusion of victims, especially in peripheral and vulnerable regions.

The production of statistical information on domestic violence is an essential instrument for the formulation of preventive public policies and institutional mechanisms for the protection of women. Sousa et al. (2024) argue that the existence of multiple databases on violence against women reveals advances in institutional monitoring, but also highlights challenges related to the standardization of information and the underreporting of cases. According to the authors, the absence of complete records makes it difficult to accurately identify the forms of property violence, since many occurrences end up classified only as psychological or moral violence.

In the Amazonian context, the analysis of the data produced by the Court of Justice of the State of Amazonas shows a significant growth in demands related to domestic and family violence. The TJAM report (2026) shows that factors such as financial dependence, social vulnerability, and affective relationships marked by economic control are often associated with episodes of violence against women in Manaus. The data presented reinforce the need to strengthen preventive policies aimed specifically at the recognition of property violence as an autonomous modality of rights violation.

In addition to the legal dimension, property violence has profound social and economic consequences for the victims. Quirino et al. (2026) observe that the patrimonial control exercised by the aggressor directly compromises women's financial independence, creating barriers to the termination of the abusive relationship. In several cases, the retention of documents, destruction of personal property and appropriation of financial resources are used as mechanisms of intimidation and submission. As the authors point out, such practices reinforce relations of structural gender inequality present in Brazilian society.

The understanding of patrimonial violence also requires an analysis of the institutional relations that exist within the scope of public policies to combat domestic violence. Costa et al. (2024) state that effective government programs should act in a preventive manner, promoting educational actions capable of deconstructing cultural patterns associated with the naturalization of violence against women. For the authors, policies limited only to criminal

repression tend to present insufficient results, especially when not accompanied by initiatives aimed at women's economic autonomy.

This perspective dialogues with the understanding presented by Gomes et al. (2025), according to which the presence of pro-women institutions directly influences the state's capacity to protect victims. The authors identify that specialized institutional structures contribute to greater welcoming, legal guidance and referral of women to social and psychological assistance services. In cities marked by urban and territorial inequalities, such as Manaus, such mechanisms become fundamental to reduce the social vulnerability of victims of domestic and property violence.

Comprehensive care for women in situations of violence is a central element in the realization of the rights provided for by Brazilian legislation. Alcantara et al. (2024) argue that the performance of public services should occur in a humanized and interdisciplinary manner, recognizing that domestic violence produces multiple impacts on the physical and mental health of victims. The authors point out that the absence of financial autonomy often makes it difficult for women to move away from the violent environment, which is why public protection policies need to incorporate actions of economic inclusion and social strengthening.

At the regional level, the Igarapé Institute (2024) points out that the Legal Amazon has particular characteristics that aggravate the obstacles to confronting violence against women. Issues related to territorial distances, insufficient public facilities and limitations in access to justice compromise the effectiveness of preventive policies. The study shows that women living in peripheral or socially vulnerable areas face greater difficulties in reporting situations of property violence, especially due to economic dependence on the aggressor.

State action in Amazonas has sought to expand prevention and protection strategies for women through intersectoral policies. The State Plan for the Prevention and Confrontation of Violence Against Women establishes actions aimed at education in rights, professional training, strengthening of the reception network and expansion of specialized services in the state. The Amazonas Public Security Secretariat (2025) argues that the fight against domestic violence requires permanent integration between security, social assistance, health, and the Judiciary, allowing for more effective institutional responses to the different forms of violence provided for in Brazilian legislation.

The effectiveness of public policies to combat domestic violence also depends on the institutional capacity to guarantee access to justice for women in vulnerable situations. In this context, Paiva et al. (2023) highlight that periods of social and health crisis increase the obstacles faced by victims, especially in relation to reporting aggressions and activating state

protection mechanisms. The authors observe that social isolation has intensified situations of economic control and financial dependence, aggravating practices of property violence in the domestic environment.

The difficulty of access to protection agencies demonstrates that the confrontation of violence against women cannot be limited to the formal existence of legal norms. Campos (2024) argues that gender-based violence has structural roots associated with historical relations of inequality between men and women. Thus, preventive public policies also need to act in the cultural and educational transformation of society, promoting mechanisms capable of deconstructing naturalized practices of economic and patrimonial domination within family relations.

When discussing the instruments for evaluating public policies, Costa et al. (2024) state that the analysis of state effectiveness should consider indicators related to prevention, protection, and assistance to victims. For the authors, the simple creation of institutional programs does not guarantee concrete results without adequate articulation between the public services responsible for the care of women. Such an understanding is relevant to Manaus, considering the structural challenges faced by the protection network in the Amazonian context.

The regional analysis presented by the Igarapé Institute (2024) shows that the Legal Amazon concentrates social factors that contribute to the maintenance of domestic violence, including economic inequality, institutional fragility, and territorial limitations in access to public policies. The study shows that patrimonial violence manifests itself even more severely in contexts marked by women's financial dependence and the precariousness of socioeconomic conditions. Thus, the formulation of preventive policies requires sensitivity to local and regional specificities.

In Amazonas, institutional actions aimed at preventing domestic violence have sought to strengthen mechanisms for welcoming and protecting victims. The State Plan for the Prevention and Confrontation of Violence Against Women establishes guidelines aimed at expanding the assistance network, training professionals and developing permanent educational campaigns. According to the Amazonas Public Security Secretariat (2025), confronting domestic violence requires integrated action between different government sectors, recognizing the social complexity of multiple forms of violence against women.

The data produced by the Court of Justice of the State of Amazonas reveal the persistence of high rates of domestic violence in the state, evidencing the need for continuous strengthening of public prevention policies. The TJAM (2026) points out that economic dependence remains a recurrent element in the abusive relationships analyzed by the justice

system, a factor directly related to property violence. This reality reinforces the importance of policies aimed at women's financial autonomy as an instrument to reduce the social vulnerability of victims.

In the field of social assistance and public health, Alcantara et al. (2024) argue that care for women in situations of violence should occur in a comprehensive way, considering the emotional, physical, and economic impacts resulting from aggressions. The authors point out that practices of property violence often compromise the victim's financial stability, making it difficult to break the bond with the aggressor. In this sense, professional qualification programs, productive inclusion and economic strengthening become fundamental prevention strategies.

Recent literature also demonstrates that the strengthening of specialized institutions contributes to the improvement of public policies for the protection of women. Gomes et al. (2025) identify that locations with a greater presence of organizations dedicated to the defense of women's rights have better conditions to cope with domestic violence. This finding highlights the need for continuous investments in the institutional structure of Manaus, especially in the face of the growing demands related to property and family violence.

In view of this scenario, it is verified that patrimonial violence against women is a complex and multifactorial phenomenon, directly associated with structural gender inequalities and institutional limitations existing in the Amazonian context. The sources analyzed demonstrate that the strengthening of preventive public policies in Manaus requires integrated action between public security, social assistance, health, education and the Judiciary, seeking to ensure effective protection, economic autonomy and guarantee of the fundamental rights of women in situations of domestic and family violence.

3 METHODOLOGY

This article is characterized as a qualitative research, developed through a literature review, with an analytical and descriptive focus on prevention policies against domestic and family violence against women, especially with regard to property violence in the context of Manaus, Amazonas. The choice of literature review is justified by the need to gather, systematize and interpret recent scientific and institutional productions on the subject, allowing a broader understanding of the mechanisms for prevention, protection and coping with this type of violence.

The research was conducted based on the selection of scientific materials and institutional documents published in the last five years, prioritizing studies with academic relevance, thematic relevance and alignment with the investigated object. Scientific articles,

institutional reports and technical documents considered reliable and compatible with the research proposal were used exclusively, enabling a critical analysis of public policies related to domestic and property violence against women in Brazil and in the Amazon region.

The bibliographic survey focused on nationally and internationally recognized academic databases, including SciELO, indexed scientific journals and official documents produced by public agencies and specialized institutions. The selection of sources considered criteria related to the identification of authorship, timeliness of publications, thematic coherence, availability of the full text, and scientific relevance for the development of the research. Materials without identifiable authorship, opinion texts, duplicate content, documents without academic validation, and publications that did not have a direct relationship with the object of the study were excluded.

The data collection stage occurred through exploratory, selective and analytical reading of the previously selected works, allowing the identification of the main concepts, legal approaches, social factors and institutional elements related to patrimonial violence against women. Subsequently, the thematic organization of the information was carried out, grouping the contents into central axes related to gender violence, public policies for prevention, institutional protection, access to justice and women's social vulnerability in the Amazonian context.

The data analysis was based on the qualitative interpretation of the content of the selected scientific and institutional productions. This procedure allowed us to identify convergences, divergences and gaps in the recent literature on the effectiveness of public policies to combat domestic and family violence against women. The analysis also made it possible to understand how economic, social and structural factors influence the occurrence of property violence and hinder female autonomy in situations of vulnerability.

The territorial delimitation of the research was concentrated in the city of Manaus, Amazonas, considering the regional specificities of the Legal Amazon and the challenges faced by the women's protection network in the state. This is justified by the social relevance of the theme in the Amazonian context, marked by social inequalities, structural limitations of access to public services and growth in demands related to domestic and family violence.

As methodological limitations, the dependence on secondary data available in the scientific productions and institutional documents analyzed is recognized, as well as the possibility of underreporting of cases of property violence recorded by official agencies. Even so, the use of recent academic sources and specialized institutional documents contributed to greater analytical consistency of the research, allowing a theoretical construction consistent

with the objectives proposed in the study.

The following table presents the main sources used in the development of this research, including scientific articles, institutional documents and technical reports related to public policies to combat domestic and family violence against women, with emphasis on patrimonial violence in the context of Manaus, Amazonas. The organization of these sources allows us to visualize the diversity of the materials used in the theoretical and methodological foundation of the study, evidencing the interdisciplinary and updated nature of the research.

Table 1

Scientific and institutional sources used in the foundation of the research

Lead author/Institution	Document Title	Font type	Year
Alcantara	Comprehensive care for women victims of violence	Scientific article	2024
Fields	Gender-based violence in the Maria da Penha Law: a concept in dispute	Scientific article	2024
Costa	Violence against women: a model for evaluating public policies	Scientific article	2024
Gomes	The existence of pro-women institutions and violence against women in Brazil	Scientific article	2025
Igarapé Institute	Violence against women in the Legal Amazon in the last five years compared to the rest of the country	Institutional technical report	2024
Paiva	The impact of the Covid-19 pandemic on access to justice for women in situations of domestic and family violence	Scientific article	2023
Quirinus	Property violence: an integrative literature review	Scientific article	2026
Amazonas Public Security Secretariat	State Plan for the Prevention and Confrontation of Violence Against Women	Official document	2025
Sousa	Sources of information on violence against women in Brazil	Scientific article	2024
Court of Justice of the State of Amazonas	Sociodemographic profile of women and perpetrators of domestic violence and the circumstances of violence in the year 2025	Official document	2026

Source: The Authors.

The analysis of the sources presented demonstrates that the research was built from recent scientific and institutional materials, allowing a multidisciplinary approach to domestic and family violence against women. There is a predominance of scientific articles focused on the analysis of public policies, gender violence, institutional protection and property violence, complemented by official documents related to the Amazonian context and the actions developed in the state of Amazonas.

This diversity of sources contributes to a greater theoretical deepening and strengthening

of the critical analysis proposed by the study, especially with regard to the challenges faced by preventive policies and the women's protection network in Manaus.

4 RESULTS AND DISCUSSIONS

The analysis of the scientific productions and institutional documents used in the present research shows that patrimonial violence remains one of the least identified and debated modalities in the context of domestic and family violence against women. Although the Brazilian legislation formally recognizes this form of violence, the results demonstrate that there are still institutional and social difficulties related to the recognition of abusive practices that involve economic control, retention of assets and limitation of women's financial autonomy. In this sense, Quirino et al. (2026) state that property violence often occurs silently, making it difficult for the victim to perceive it and for adequate state intervention.

The data analyzed also reveal that property violence is directly associated with structural relations of gender inequality. Campos (2024) highlights that gender-based violence cannot be interpreted in isolation, since it stems from historical patterns of male domination and female subordination present in Brazilian society. This understanding allows us to observe that patrimonial control constitutes a mechanism for maintaining the power exercised by the aggressor within family relations, compromising the economic and social freedom of women.

In the Amazonian context, the results indicate that territorial and socioeconomic vulnerabilities intensify the challenges faced by women victims of domestic violence. The Igarapé Institute (2024) shows that the Legal Amazon presents structural obstacles related to access to public services, institutional action, and the protection of victims, especially in locations marked by social inequalities and precarious state presence. In Manaus, such difficulties directly reflect on the ability of women to report situations of property violence and seek legal and social assistance.

The analysis of the State Plan for the Prevention and Confrontation of Violence Against Women shows important institutional advances in the state of Amazonas. The Amazonas Public Security Secretariat (2025) points out that state policies have sought to expand educational actions, strengthen the protection network, and promote integration between public security, social assistance, and the justice system. However, the results observed demonstrate that there are still limitations related to the coverage of specialized services and the effective implementation of preventive policies in all urban and peripheral areas of Manaus.

Another relevant aspect identified in the research refers to the importance of specialized institutions in dealing with domestic violence. Gomes et al. (2025) observe that the presence of

pro-women organizations contributes significantly to improving institutional protection, especially through the legal and social support of victims. The results suggest that municipalities and states with more consolidated specialized structures have better conditions to cope with domestic violence, including with regard to property violence practices.

The production of statistical information also proved to be an essential element for understanding the investigated problem. Sousa et al. (2024) state that the existence of databases on violence against women allows for greater social visibility of the problem and contributes to the formulation of more efficient public policies. However, the authors warn that underreporting still represents a relevant obstacle, especially in cases of property violence, which are often made invisible in institutional records and formal complaints.

The data presented by the Court of Justice of the State of Amazonas show a significant growth in demands related to domestic and family violence against women in recent years. The TJAM (2026) shows that factors such as financial dependence, economic vulnerability, and lack of adequate institutional support appear recurrently in the situations analyzed by the state justice system. This reality reinforces the need to strengthen preventive public policies aimed at women's economic autonomy and the patrimonial protection of victims.

In addition to the legal and social consequences, the results indicate that property violence produces significant impacts on women's physical and emotional health. Alcantara et al. (2024) highlight that practices of economic control and financial restriction often trigger psychological suffering, social insecurity, and difficulties in breaking the cycle of violence. The authors argue that effective public policies should adopt an interdisciplinary and humanized approach, considering the multiple effects produced by different forms of domestic violence.

The analysis of the selected sources demonstrates that public policies to combat domestic violence are more effective when structured in an integrated and continuous manner. Costa et al. (2024) state that isolated and exclusively repressive actions have significant limitations in the prevention of violence against women, especially in cases where the victim remains economically dependent on the aggressor. The results identified in this research indicate that the absence of policies aimed at women's financial autonomy contributes to the maintenance of cycles of property violence in the family environment.

In this scenario, it is observed that property violence assumes a strategic role within abusive relationships, functioning as an instrument of control and submission of the victim. Quirino et al. (2026) highlight that practices such as withholding documents, destroying personal belongings, controlling wages, and preventing access to financial resources directly compromise women's ability to be independent. The results analyzed reveal that such behaviors

often occur in a manner associated with psychological and moral violence, increasing the social and emotional damage suffered by the victims.

Women's economic vulnerability appears as a recurrent factor in the discussions present in the sources analyzed. According to Alcantara et al. (2024), women subjected to property violence tend to have greater difficulty in breaking the abusive bond, especially due to the lack of financial conditions to reorganize their own lives. The authors emphasize that public policies for reception need to incorporate programs for productive inclusion, professional qualification and economic strengthening, especially in regions marked by social inequality.

In the context of Manaus, the results demonstrate that the geographical and social particularities of the Amazon directly influence the effectiveness of public policies for the protection of women. The Igarapé Institute (2024) shows that the insufficiency of specialized public equipment and the difficulties in accessing institutional services contribute to the weakening of the protection network in the Legal Amazon. This reality becomes even more worrying in the face of the growth in demands related to domestic and family violence registered by public agencies in Amazonas.

The performance of the state Judiciary also represents an important element in the fight against domestic violence. Data from TJAM (2026) show an increase in occurrences involving relationships marked by economic dependence and asset control exercised by the aggressor. The results analyzed indicate that many victims arrive at the justice system already inserted in prolonged contexts of psychological, financial and social violence, evidencing the need to strengthen preventive and educational measures aimed at protecting women.

At the institutional level, Gomes et al. (2025) emphasize that the presence of specialized organizations contributes to greater efficiency of public policies for the protection of women. The authors identify that specialized police stations, reference centers and reception programs have a positive impact on reducing the social vulnerability of victims, especially when articulated with legal, psychological and social assistance services. In Manaus, such mechanisms become fundamental in view of the structural limitations faced by the public protection network.

The results also highlight the importance of producing and systematizing information on domestic and property violence. Sousa et al. (2024) state that the absence of standardized records hinders the formulation of more effective public policies, in addition to compromising the real understanding of the dimension of property violence in Brazil. The research shows that underreporting remains one of the main obstacles to confronting violence against women, especially in contexts of economic vulnerability and financial dependence.

Another relevant aspect identified refers to the need to strengthen educational and

preventive actions aimed at deconstructing gender violence. Campos (2024) argues that confronting domestic violence requires cultural transformation capable of breaking historical patterns of inequality between men and women. The results obtained indicate that public policies focused only on the criminal accountability of the aggressor tend to have limited scope when not accompanied by educational, social and economic initiatives aimed at the full protection of women.

The results obtained in the present research demonstrate that property violence remains inserted in a context of social and institutional invisibility, even in the face of the legislative advances promoted by the Maria da Penha Law. The analyses carried out indicate that many women do not recognize certain practices of economic control as forms of domestic violence, a factor that hinders both the denunciation and the preventive action of the State. As observed by Quirino et al. (2026), patrimonial violence often manifests itself in a silent and progressive way, becoming an instrument for maintaining female dependence and submission.

The analysis of public policies shows that the integration between the different bodies of the protection network represents an indispensable element for coping with domestic and family violence. The Amazonas Public Security Secretariat (2025) points out that articulated actions between public security, social assistance, health, and the Judiciary expand the institutional capacity to welcome and protect victims. The results of this research demonstrate that the lack of integration between these sectors significantly reduces the effectiveness of preventive measures and hinders the full protection of women in vulnerable situations.

Another aspect identified refers to the influence of socioeconomic inequalities in the perpetuation of property violence. Costa et al. (2024) state that economically dependent women face greater obstacles to breaking abusive relationships, especially in contexts marked by precarious access to public policies. In Manaus, the results analyzed suggest that factors related to social vulnerability, unemployment and limitation of specialized services intensify the impacts of domestic violence and compromise female autonomy.

At the regional level, the Igarapé Institute (2024) shows that the states of the Legal Amazon have specific structural difficulties related to the protection of women victims of violence. Territorial issues, institutional limitations and inequality in the distribution of public services contribute to the fragility of the network to combat domestic violence. The results of the present research reinforce that such factors have a direct impact on the ability of victims to access reporting mechanisms, legal assistance and social support in the state of Amazonas.

The performance of specialized institutions has also been shown to be relevant in reducing the vulnerability of women victims of property violence. Gomes et al. (2025) observe

that pro-women organizations play a fundamental role in promoting legal, psychological, and social assistance, strengthening institutional protection and expanding victims' access to their rights. In Manaus, the results indicate that the strengthening of these structures can contribute significantly to the improvement of public policies to prevent and cope with domestic violence.

In addition to the institutional dimension, the results demonstrate that property violence has profound impacts on the emotional and social health of victims. Alcantara et al. (2024) state that financial control and economic restriction often trigger psychological distress, social insecurity, and reduced female self-esteem. The research shows that women subjected to property violence tend to face greater difficulties in rebuilding personal and financial autonomy, reinforcing the need for interdisciplinary and humanized public policies.

The data analyzed by the Court of Justice of the State of Amazonas reveal a continuous growth in demands related to domestic and family violence against women. The TJAM (2026) demonstrates that economic factors are often associated with situations of violence analyzed by the state justice system. This reality confirms that property violence cannot be treated as a secondary aspect of abusive relationships, but rather as a central mechanism for controlling and perpetuating gender violence.

The results obtained show that the confrontation of patrimonial violence against women in Manaus requires strengthening preventive public policies, expanding the institutional protection network and developing strategies aimed at women's economic autonomy. The research demonstrates that the fight against domestic violence requires multidisciplinary and continuous action, involving not only legal repression, but also educational, social and economic actions capable of reducing structural inequalities and promoting effective guarantee of women's rights.

Table 2 below presents a synthesis of the main scientific and institutional productions used in the development of the research, highlighting the objectives, methods employed and main results identified in each study. The organization of this information allows a better visualization of the theoretical and analytical panorama related to public policies for the prevention of domestic and family violence against women, with emphasis on property violence and the Amazonian reality.

Table 2*Synthesis of the studies used in the research*

Authors	Objective	Method	Main results
Alcantara et al. (2024)	Analyze comprehensive care for women victims of violence	Qualitative study and literature review	It highlighted the need for interdisciplinary care and strengthening of women's economic autonomy
Fields (2024)	Discuss the concept of gender-based violence in the Maria da Penha Law	Legal and bibliographic analysis	It demonstrated that gender violence stems from structural relations of social inequality
Costa et al. (2024)	Evaluate public policies aimed at confronting violence against women	Analytical study of public policies	It identified that integrated actions are more effective in protecting victims
Gomes et al. (2025)	Investigate the influence of pro-women institutions in confronting violence	Quantitative and documentary research	It found that specialized bodies strengthen institutional protection
Igarapé Institute (2024)	Analyzing violence against women in the Legal Amazon	Technical report and statistical analysis	He pointed out structural vulnerabilities and difficulties in accessing the protection network
Paiva et al. (2023)	Examining the impacts of the pandemic on access to justice for women victims of violence	Qualitative and documentary research	Demonstrated increased difficulties in reporting and protection during periods of crisis
Quirino et al. (2026)	Review the literature on property violence against women	Integrative literature review	It identified social invisibility of property violence and association with financial dependence
Amazonas Public Security Secretariat (2025)	Establish state strategies to combat violence against women	Institutional technical document	Defined integrated actions for prevention, protection and strengthening of the state network
Sousa et al. (2024)	Analyze the sources of information on violence against women in Brazil	Desk research and data analysis	It showed statistical limitations and underreporting of cases of property violence
Court of Justice of the State of Amazonas (2026)	To present a sociodemographic profile of the occurrences of domestic violence in the state	Institutional statistical report	It indicated an increase in demands related to domestic violence and economic dependence

Source: The Authors.

The joint analysis of the sources presented shows convergence between studies regarding the complexity of domestic and family violence against women, especially with regard to property violence and the difficulties faced by victims to break abusive relationships marked by economic dependence. It is observed that the selected works emphasize the need to strengthen preventive public policies, expand interinstitutional action and develop strategies aimed at women's financial autonomy.

In addition, institutional documents and regional reports demonstrate that the Amazonian context presents specific challenges related to social vulnerability, the structural limitation of public services and access to the protection network, factors that make it essential to build

integrated and regionally adapted measures to confront violence against women in Manaus, Amazonas.

5 CONCLUSION

The present research allowed us to understand that patrimonial violence against women constitutes one of the most silent and complex forms of domestic and family violence, producing significant impacts on the economic, emotional and social autonomy of the victims. The analysis of scientific productions and institutional documents showed that this type of violence remains strongly associated with structural gender inequalities, functioning as a mechanism for controlling and perpetuating abusive relationships within the family environment.

The results obtained showed that, although there are normative and institutional advances aimed at confronting violence against women, there are still limitations related to the effectiveness of preventive public policies, especially in the Amazonian context. In Manaus, factors such as social vulnerability, economic dependence, structural limitations of the protection network, and difficulties in accessing public services contribute to the intensification of the challenges faced by women victims of property violence.

The research also showed that the strengthening of specialized institutions and the intersectoral action of the State represents a fundamental element for improving prevention and protection policies for women. The integration between public security, social assistance, health and the Judiciary proved to be indispensable to guarantee adequate reception, access to justice and full protection of victims, especially in view of the complexity of the multiple forms of domestic violence identified in the study.

Another relevant aspect observed refers to the need to expand public policies aimed at women's financial autonomy. It was found that economic dependence is a determining factor for the permanence of victims in abusive relationships, making it essential to develop strategies for productive inclusion, professional qualification and economic strengthening of women in situations of social vulnerability.

Therefore, the confrontation of property violence against women in Manaus requires continuous, integrated and multidisciplinary action, involving not only repressive measures, but also educational, preventive and social actions capable of reducing structural inequalities and promoting effective protection of women's rights. In addition, the research reinforces the importance of expanding scientific studies focused on property violence, considering the need for greater academic, institutional and social visibility of this form of domestic violence in the Amazonian context.

ACKNOWLEDGMENTS

The accomplishment of this work represents not only the conclusion of academic research, but also the strengthening of the commitment to the defense of human dignity, social justice and the protection of women's rights. The theme addressed reinforces the importance of scientific production as an instrument of critical reflection and social contribution, especially in the face of the challenges faced in combating domestic and family violence against women in the Amazonian context.

We thank all the professors, colleagues and professionals who contributed directly or indirectly to the development of this research, whether through academic encouragement, scientific discussions or the sharing of fundamental knowledge for the construction of this study. The support received throughout this trajectory was essential for the maturation of the analyses and for the consolidation of the proposed objectives.

We also register our gratitude to the public, scientific and social institutions that develop actions to combat violence against women and produce data, research and public policies aimed at protecting women. May this work contribute, even if in a modest way, to the expansion of the academic debate and strengthening of strategies for prevention, reception and guarantee of women's rights in Manaus, Amazonas, and throughout the Amazon.

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BETWEEN EMANCIPATION AND PROTECTION: THE LIMITS OF AUTONOMY FOR VULNERABLE GROUPS FROM A TRANSFORMATIVE CONSTITUTIONAL PERSPECTIVE

ENTRE A EMANCIPAÇÃO E A PROTEÇÃO, OS LIMITES DA AUTONOMIA DOS VULNERÁVEIS NA PERSPECTIVA CONSTITUCIONAL TRANSFORMADORA

ENTRE LA EMANCIPACIÓN Y LA PROTECCIÓN: LOS LÍMITES DE LA AUTONOMÍA PARA LOS GRUPOS VULNERABLES DESDE UNA PERSPECTIVA CONSTITUCIONAL TRANSFORMADORA



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ABSTRACT

This article analyzes the tensions between autonomy and the protection of vulnerable subjects, especially children, adolescents, young people, the elderly, and people with disabilities, in light of transformative constitutionalism. Starting from human dignity and Fineman's theory of vulnerability, it examines the normative shaping of civil capacity after the Convention on the Rights of Persons with Disabilities, the Statute of Persons with Disabilities, and the 2015 Code of Civil Procedure. Empirical data from the National Council of Justice (CNJ) and decisions of the Superior Court of Justice (STJ) reveal the gap between the normative promise and the reality. It argues for the need for structural criteria to effectively balance autonomy, guardianship, and supported decision-making, avoiding both paternalism and abandonment.

Keywords: Constitutional Vulnerability. Autonomy. Transformative Constitutionalism. Legal Framework.

RESUMO

O artigo analisa as tensões entre autonomia e proteção de sujeitos vulneráveis, especialmente de crianças, adolescentes, jovens, idosos e pessoas com deficiência, à luz do constitucionalismo transformador. Partindo da dignidade humana e da teoria da vulnerabilidade de Fineman, examina-se a conformação normativa da capacidade civil após a Convenção da Pessoa com Deficiência, o Estatuto da Pessoa com Deficiência e o Código de Processo Civil de 2015. Dados empíricos do CNJ e decisões do STJ revelam a distância entre a promessa normativa e a sala de máquinas. Defende-se a necessidade de critérios estruturais para equilibrar efetivamente autonomia, curatela e tomada de decisão apoiada, evitando tanto o paternalismo quanto o abandono.

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Palavras-chave: Vulnerabilidade Constitucional. Autonomia. Constitucionalismo Transformador. Sala de Máquinas.

RESUMEN

Este artículo analiza las tensiones entre la autonomía y la protección de los sujetos vulnerables, especialmente niños, adolescentes, jóvenes, ancianos y personas con discapacidad, a la luz del constitucionalismo transformador. Partiendo de la dignidad humana y la teoría de la vulnerabilidad de Fineman, examina la configuración normativa de la capacidad civil tras la Convención sobre los Derechos de las Personas con Discapacidad, el Estatuto de las Personas con Discapacidad y el Código de Procedimiento Civil de 2015. Datos empíricos del Consejo Nacional de Justicia (CNJ) y decisiones del Tribunal Superior de Justicia (TSJ) revelan la brecha entre la promesa normativa y la realidad. Se argumenta a favor de la necesidad de criterios estructurales para equilibrar eficazmente la autonomía, la tutela y la toma de decisiones con apoyo, evitando tanto el paternalismo como el abandono.

Palabras clave: Vulnerabilidad Constitucional. Autonomía. Constitucionalismo Transformador. Marco Jurídico.

1 INTRODUCTION

The protection of vulnerable groups in Brazil was indelibly marked by the Federal Constitution of 1988, which established guidelines for the protection of fundamental rights in relation to all subjects and, in particular, for those who demand special constitutional protection.

Within the scope of Title VIII of the Constitution, which deals with the Social Order, the constitutional text distinguished a specific Chapter, VII, to deal with "the Family, the Child, the Adolescent, the Youth and the Elderly". This will be exactly the group in a situation of vulnerability considered in this article, adding people with "physical, sensory or mental disabilities", under the terms of article 227, II, without disregarding the perspective that vulnerability is an inherent element of humanity itself.

The constitutional proximity in relation to the establishment of fundamental rights and guarantees in relation to these vulnerable groups, in a different way from the previous historical paradigm, related to the military dictatorship and tainted by several confrontations with the principle of human dignity, is in line with the historical development of Transformative Constitutionalism, especially from the 1990s onwards. This transformative perspective is based on the allocation of all branches of law by the prescriptions of the Constitution, in addition to evaluating the elements of private relationships, including family relationships, based on constitutional principles and guarantees.

However, constitutional transformation does not take place automatically, since it depends on institutional and structural arrangements capable of operationalizing constitutional norms. Thus, even though the Brazilian Constitution has expanded rights and guarantees, practices and structures persist that limit the autonomy of the subjects it seeks to protect, reproducing tutelary and paternalistic logics incompatible with the 1988 constitutional project.

From these bases, this article intends, through the hypothetical-deductive method, of a qualitative nature, based on the analysis of normative, jurisprudential and empirical evidence, to answer the following research question: how to delimit the autonomy of constitutionally protected subjects, so as not to compromise the reinforced protection that is ensured by the Constitution, from the transformative perspective?

In this sense, the general objective is to analyze the limits of the autonomy established by the Constitution for vulnerable groups, considering the imperfections existing in the engine room and its essentiality for the constitutionally instituted rights and programs to be achieved. The constitutional bases for the protection of these groups, the normative conformation of civil capacity in the current legislation, and the evaluation of empirical data and jurisprudence, which reveal the distance between the normative promise and the engine room, must be examined.

The article is structured in two development sections, in addition to this introduction and conclusion: section 2 examines the constitutional foundations of human dignity and vulnerability; Section 3 looks at transformative constitutionalism and the concept of the engine room applied to the protection of the vulnerable.

2 DIGNITY OF THE HUMAN PERSON AND VULNERABILITY: THE BASES OF THE FEDERAL CONSTITUTION OF 1988

Human dignity and fundamental rights and guarantees have gone through a long historical process so that the perspectives that exist today were achieved.

While the eighteenth and nineteenth centuries were marked by the advance of individual rights, directed by liberalism, the advance of social rights together with the maturation of the recognition of individual rights advanced especially in the twentieth century. based on Locke's philosophy (Fineman, 2008).

The Second World War, characterized by the massive violation of human rights in the Nazi-fascist regimes, was a turning point in the recognition and prioritization of human rights and inviolable fundamental rights, encompassing life and human dignity (Tamanaha, 2004, p. 109).

After this period, there was a transformation in constitutional texts around the world, which began to recognize the centrality of human dignity (Grimm, 2016, p. 161), although they depended on effective measures for the materialization of constitutional texts. In this context, the conjunction of socioeconomic, political and legal factors inherent to the post-war II period, marked in several Western countries by the transition from authoritarian and exclusionary regimes to democracies, served as a catalyst for the incorporation of various human and social rights inherent to the ongoing social transformations, generating a transition, empirically perceptible, to more verbose constitutions, especially in the field of fundamental rights (Freire, 2021).

Thus, the second half of the twentieth century saw formal structural changes in the constitutions, with evidence in the constitutions of Italy, 1947, Germany, 1949, which influenced the Charters of late democracies, such as the Constitution of Greece, 1975, Portugal, 1976, and Spain, 1978, including, in this field, states marked by dictatorships, the Latin American constitutions of the end of the century (Assumpção, 2022), which began to include a broad list of rights, understood as elements of social transformation.

Fundamental human rights have undergone this long trajectory of change, initially gaining constitutional stature and, consequently, sheltering positive law (Bobbio, 2004, p. 19),

enabling the action of constitutional courts established throughout the twentieth century, with the exception of the United States (which has a different trajectory in relation to its Constitutional Court), for the protection of these rights.

In line with this historical transition, the Constitution of the Federative Republic of Brazil, of 1988, is the culmination of the transition process from a dictatorial and military regime, which began in the 1960s, to a democratic federative model, based on the dignity of the human person. The Brazilian Constitution represents, in this sense, the materialization of the aspirations for changes existing in the Nation, bringing a model of democratic interactions that prioritized the dignity of the human person (Teixeira, 2018), with a broad list of fundamental rights that began to direct the political and social relations of the State (Piovesan; Hernandez, 2024), definitively breaking with the dictatorial model in force until then.

In line with the prioritization of the dignity of the human person and fundamental rights, the Federal Constitution has among its foundations, provided for in the first article of the Charter, pluralism (item V), which is added to the dignity of the human person (III) and allows different conceptions of what is "good" to be structured, according to individual convictions (Teixeira, 2018), allowing the recognition of individuals as subjects of rights in their *individualities*, not as a mere agglomeration of people.

Aiming to embody this consideration of rights from plural perspectives of individuality, the Federal Constitution of 1988 makes specific considerations about individuals in situations of vulnerability, based on the principle that in these conditions intersubjectivity becomes a necessity for the enjoyment of constitutionally provided rights (Teixeira, 2018), due to physical or psychological fragility.

The Constitution ends up reconciling the elements of freedom and solidarity, inherent to human dignity, with the characteristics related to vulnerability, directing, in the family environment, special protection for children, adolescents, the elderly and people with disabilities (Teixeira, 2018). The current Charter of the Republic, in its article 226, reaches the family as the base of society, establishing a series of protections by the State, including in relation to the family entity, establishing a multivariate form of family.

In this sense, the Federal Constitution included in the scope of the concept of family the community formed by any of the parents and their descendants which, added to the judgment, by the Federal Supreme Court, of the Direct Action of Unconstitutionality No. 4277 and the Action for Non-Compliance with a Fundamental Precept No. 132, expanded the concept of family, including changes in the social sphere, anchored in fundamental principles and, in particular, in the dignity of the human person.

In the same title in which it deals with families, especially in article 227, the Federal Constitution establishes a series of rules aimed at the protection of children, adolescents and people with disabilities, expressly defining such groups as special protection groups.

Os Arts. 229 and 230, in turn, focus on the protection of the elderly, clarifying rights and establishing obligations aimed at the effectiveness of this protection, once again considering elements of human dignity and the guarantee of the right to life. It is noted, therefore, that the Citizen Constitution established a series of fundamental rights and guarantees directed to these groups, breaking with the previous constitutional tradition, still demarcated by the influence of the dictatorship, while establishing obligations for state action, even in the field of family entities, for the protection of groups in situations of vulnerability.

In 2009, the International Convention on the Rights of Persons with Disabilities was added to the 1988 constitutional text, which inaugurated the incorporation of human rights norms with constitutional stature into the Brazilian legal system, and structured a series of requirements and safeguards for the exercise of legal capacity by persons with disabilities (Rosenvald, 2018). One of the central elements of the manifestation of the will and preferences of persons with disabilities becomes, within the scope of the Convention, the exemption from conflict of interest and undue influence, mentioning the principle of proportionality for the provision of these guidelines.

In this field, it is necessary to establish a terminological distinction that is essential for understanding the limits of this study. Although the Supreme Court itself is not theoretically precise when it uses terms related to vulnerability (Vargas; Leal, 2023), the focus of this work is on the limits of Title VIII of the Constitution, specifically in relation to the constitutionally protected groups of Children, Adolescents, Youth, Elderly, and Persons with Disabilities, in line with Teixeira's (2018) perspective of family protection.

This cut is necessary especially due to the restrictions on the private autonomy of these individuals, resulting from both normative and factual bases, considering the conditions that individuals can achieve throughout their lives. Given the relational character of vulnerability, which manifests itself from the interaction between different subjects, one stronger and the other less resistant, which subordinates the latter to a condition susceptible to harm (Machado, 2023), the theme of protection gains even more relevance, considering that the conditions that characterize the situation of vulnerability are manifested precisely in relationships dependent on the manifestation of will in an autonomous and conscious way.

In view of this theoretical field, although the discussion on the concept of autonomy is the subject of extensive debates, which are beyond the scope of this article, the term will be

used in reference to a free will, intrinsically related to the self-determination of subjects, self-governed by their own will and not by the will of others, in line with the perspective used by Barroso (2012).

Based on these delimitations, vulnerability becomes a concrete form, which must be considered for the materialization of human dignity both in the public and private spheres (Gama; Bridges; Teixeira, 2014), which must consider the limitations of each subject in their relationships. In the same sense, it must be considered with regard to the availability of first-generation fundamental rights, especially freedom and private autonomy, which can be attenuated due to material conditions of vulnerability (Teixeira, 2018).

Although the dignity of the human person can be presented as the axiological foundation of the Brazilian constitutional order, it is necessary to recognize that, in relation to the subjects of special constitutional protection, dignity operates not only as a limit to the State's discretion, but above all as a structural condition for the exercise of autonomy. In this sense, dignity, as mentioned, assumes a relational character and is based on the individual's capacities, requiring the State and the family to create material, affective and institutional conditions that allow children, adolescents, the elderly and people with disabilities to develop their own life projects. It is a conception that moves away from the classical liberal notion of autonomy as a mere negative freedom and adheres to a substantial understanding, according to which autonomy is only possible when the subject has adequate means to exercise it, especially in contexts of age, ontological or functional vulnerability.

Adding to the debate on the limits of freedom and its relationship with human dignity, the discussion about the submission of civil relations to fundamental rights is not recent, dating back to the Lüth-Urteil case (centered on freedom of expression), in which the German Constitutional Court ruled on the horizontal application of constitutional norms, in all branches of law (Leal, 2007, p. 64-67).

In Brazil, this discussion was impacted by the Federal Constitution of 1988, with decisions within the scope of the Federal Supreme Court that mark the position of Brazilian jurisprudence in the sense of affecting private relations by fundamental rights, with milestones in Extraordinary Appeal 201.819-8/RJ, which dealt with the application of fundamental rights in the context of private associative relations, and in Direct Action of Unconstitutionality 4815, which was also based on the discussion about freedom of expression, specifically about the need for prior authorization for the publication of biographical documents.

In the infra-constitutional sphere, relevant changes occurred with the advent of the Statute of Persons with Disabilities and the Code of Civil Procedure, both in 2015, which inflicted

robust changes in the relational field of people subject to vulnerabilities, with strong criticism in the scope of Civil Law for enabling curatorship related to legally capable people (Lago Júnior; Barbosa, 2016), considering that the parameters of civil capacity structured in the Civil Code of 2002 were changed.

To give effect to the new civil parameters, the normative changes included mechanisms to support autonomy, especially through Supported Decision Making, structured in article 1,783-A, of the Civil Code, which would be framed as a distinct element of assistance in the case of limitations to the definition and manifestation of the elements of will (Rosenvald, 2018). In the same sense, curatorship began to be framed in an exceptional way, subject to specific planning and based on the individual therapeutic elements of each subject (Rosenvald, 2018), observing the constitutional guidelines, including the established principles, increased by the Convention on Persons with Disabilities.

Ten years after the legal changes, it is possible to see that despite the good normative intentions, the practical effects of the new regulations are paradoxical, considering that the institutes to support the vulnerable have not been fully applied and that the curatorship has been applied indistinctly, covering several cases of specific limitations, due to the difficulty of individualized monitoring of the capacities of the subjects.

In the end, as mentioned, capable people (based on the text of the Civil Code in force) are being submitted to the institute of curatorship without the proper restrictions and, at the other extreme, subjects in need of support are susceptible to decisions and businesses that are not aligned with their real interests, due to the lack of support for decision-making.

It is precisely in this extreme situation in relation to the vulnerable that the transformative constitutional perspective becomes a relevant theoretical tool, given that it analyzes the effectiveness of the norm and the role of judges and legal culture from a broad view, considering the institutional elements inherent to the realization of rights.

In this context, dignity fulfills the function of a normative axis capable of balancing protection and autonomy, functioning both as a foundation for state intervention and as a limit to excessive protection. Dignity prevents protection from becoming an annulment of personality, at the same time that it prevents an abstract defense of autonomy from putting at risk subjects that the Constitution has assumed as priorities.

The legal system must therefore recognize that dignity requires a complex balance, in which state or family intervention is proportional to the degree of vulnerability and always oriented to strengthening the subject's capacity for self-determination. If dignity is the foundation of reinforced protection, it is also in it that the foundation of the autonomy of the constitutionally

protected subjects is located. The theoretical and practical challenge, however, lies in reconciling protection and autonomy without incurring either paternalism or abandonment, a tension that is especially relevant in the light of the transformative constitutional perspective.

3 TRANSFORMATIVE CONSTITUTIONALISM AND RECOGNITION OF THE "ENGINE ROOM" IN THE PROTECTION OF THE VULNERABLE

Transformative Constitutionalism is a doctrinal perspective that starts from the premise that the norm does not have material effects in itself, especially the fundamental rights and guarantees established in the Constitution, although it recognizes that the effectiveness of fundamental rights is full, using the classification of José Afonso da Silva (1998) as a reference.

With the debate marked especially from the article *Legal Culture and Transformative Constitutionalism*, by Karl E. Klare (1998), Transformative Constitutionalism can be defined as a perspective of effective judicial action aimed at the transformation of society, based on the interpretation and application of constitutional norms in a way that brings changes in political and social institutions. in the context of a favorable historical and political context (Klare, 1998).

In this line, the transformative theoretical perspective studies and considers the movements of all agents who work in the judicial field, not just judges. Thus, the role of lawyers and doctrine in the transformation of legal culture is highlighted, considering that the recognition of the existing procedural limitations depends, at first, on recognition from doctrine and the harmonization of discussion methods, especially legal argumentation, based on the performance of lawyers (Klare, 1998).

The focus on the implications in the social field of norms and judicial decisions is a central element, which is analyzed, in Transformative Constitutionalism, together with the constitutional body itself, so that this theoretical prism analyzes the Constitution and the Laws not only as norms, but as a constitutional project (Arguelhes; Sússekind, 2022) that must be achieved from both regulations and court decisions. For this reason, in the transformative logic, the political and moral values of the judge should be used as beacons for his decisions (Langa, 2006), even if they are committed to impartial processes.

By using terms and evaluative questions to stimulate transformative judgments, the transformative perspective is based on the premise that legal texts do not represent, in themselves, a legal norm that must be interpreted based on the textual components. Originating from this point, transformative legal reasoning considers both cultural elements (especially legal culture) and other subjective foundations that define evaluative concepts (Klare, 1998).

As a result of this recognition, transformative theory developed the concept of "machine room", which refers to the organization of political, administrative, and legal power structures, responsible for the provision of constitutional rights and guarantees (Gargarella, 2016), involving social structures and relations, including outside the sphere of procedural action and the Judge State (Arguelhes and Sússekind, 2022).

Based on the contributions of Gargarella (2016), Roa Roa (2023), and Arguelhes and Sússekind (2022), it is possible to delimit the meaning and scope of the term "engine room" in the context of transformative constitutionalism. The engine room refers to the *organization of the power structures that enable the constitutionally provided fundamental rights, including the political, legal and administrative apparatus responsible for the recognition and realization of these rights, in addition to the structural organization of public administration and public policies based on the Constitution.*

The engine room represents, therefore, the entire political, social and institutional framework (in particular) in which the protection of the vulnerable is structured on a daily basis, including both their private relationships and their administrative connections, which require actions by the public authorities to guarantee the autonomy and protection of the subjects.

At this point, a central element in the sphere of the contemporary engine room is the distinction between a paternalistic and patrimonialist conception in relation to the rights of the vulnerable, based exclusively on the criterion of the age or condition of the person with disabilities, which completely removes from these individuals the ability to decide about their lives (Gama; Bridges; Teixeira, 2014), in comparison with a conception of an autonomous life, but with protection, which considers the individuality and needs of each subject.

Also in the case of vulnerable individuals, especially people with disabilities and those undergoing medical treatment, this institutional framework also involves the doctor-patient relationship, which must move from a paternalistic perspective to a relationship based on constitutional elements, which considers the patient's autonomy in this area (Meirelles; Vasconcelos, 2023), without any decision being transferred to a third party.

The balance of these administrative and institutional actions is what enables the autonomy and protection of the vulnerable, without a paternalistic action and, therefore, limiting the constitutional rights of which they are holders. This central aspect must be verified, in the theoretical and practical field, from the perspective of Rosenvald (2018) based on the individuality of each subject, covering possible therapeutic elements, individual needs and capacities of each one.

This need to verify individualities is what overflows the limits of the existing engine room, both in the private and public spheres. The reforms carried out through the Statute of Persons with Disabilities and the Code of Civil Procedure, both in 2015, focused on normative changes, without the institutional mechanism where constitutional rights are realized being achieved or modified.

Without these structural changes in the engine room, the autonomy measures made possible by the normative changes since 2015, although aligned with the constitutional requirements and the Convention for Persons with Disabilities, may have the effect of reducing the protections due to specially protected individuals, given that unprotected autonomy becomes an increase in the vulnerabilities of groups specially protected by the Federal Constitution of 1988. State action in this field, with a focus on the preservation of fundamental rights and guarantees, becomes central, with the purpose of establishing material equality with regard to the rights and guarantees provided for in the Constitution, demanding effective actions for the realization of equality (Fineman, 2008).

Thus, even if the relationships of vulnerable groups occur within the family, the intervention of the State is justified by virtue of the inequalities that can emerge even in this most intimate sphere of private relations, evidenced through violence, abandonment or, at the other extreme, through undue interference in the most elementary self-determination of vulnerable subjects (Fachin, 2011).

It cannot be forgotten, in any legal analysis on the matter, that the groups specially protected by the Constitution of the Republic (which textually evidences their propositions in the epigraphed articles) *are vulnerable*, and this is precisely the core of the need for special attention on the part of society and the law (Gama; Bridges; Teixeira, 2014), without ceasing to be, for this reason, subjects of rights in all spheres of their lives.

Another effect of legal changes without the corresponding change in the engine room is the ineffectiveness of the rules, as occurs in the analysis of curatorship by the Judiciary. From the Statute of Persons with Disabilities, curatorship became a restricted legal institute, focused on people's patrimonial issues, without affecting existential elements, with a focus on valuing the autonomy of the will of the person with disabilities (Meirelles; Vasconcelos, 2023).

Despite being well-intentioned, the changes in the normative frameworks related to curatorship still face difficulties in verifying ordinary legal life. In practice, what we are witnessing is a profusion of decisions related to curatorship without the determination of individualities and covering all aspects of the curator's life, including issues inherent to existential autonomy.

According to data from the National Council of Justice, the number of new cases related to the Appointment of Curators increased from 49,267 cases in 2020 to 79,057 cases in 2024 (an increase of 60.5% in the number of cases), with a projection of up to 83,000 new cases of this type in 2025 (CNJ Statistical Panel, 2025). In the same sense, the number of Curatorship processes in general increased from 18,168 cases in 2020 to 30,636 cases in 2024 (an increase of 68.5% in the number of new cases in this period). This shows the annual growth of around 12.56% per year, while the elderly population in Brazil grows 3.8% per year, according to data from the 2022 Census (Brazilian Institute of Geography and Statistics); the Brazilian Inclusion Law (LBI) has not been able to slow down, therefore, the increase in cases of curatorship in relation to this vulnerable group, although this was one of the objectives of the rule.

Also according to information from the National Council of Justice (2023, p. 28), the percentage of curatorship processes that use Supported Decision Making, an institute inseparable from curatorship, corresponds to only 7% of the total number of processes related to curatorship, showing, once again, a legal practice dissonant with legal expectations. Such a quantitative discrepancy reinforces the need for a transformative approach that integrates empirical data to monitor institutional effectiveness. Also according to the CNJ itself, confusion between the institute of Supported Decision Making and other legal institutes is common (CNJ, 2023, p. 29).

In fact, in view of this exponential increase in the number of lawsuits, the Superior Court of Justice has made several provisions of the Code of Civil Procedure and the Civil Code more flexible, with the changes made by the Statute of Persons with Disabilities, due to the impossibility of applying the rules in their entirety in the current legal and social scenario. For example, the requirement of the Medical Report established in article 750 of the CPC was relaxed in case of refusal of the curator to perform the examination (REsp 1.933.597/RO) and in other exceptional cases. In the case of the restriction of curatorship to the patrimonial elements of the person with disabilities, the STJ admitted the possibility of broad and absolute curatorship, involving existential elements of the person (REsp 2.013.021/MG). In addition, the STJ recognized that shared curatorship, provided for in article 1,775-A of the Civil Code for the protection of the curatorship and for the mitigation of the risks inherent to this procedure, is not mandatory and cannot be granted ex officio by the judge in the case.

In these decisions, the Superior Court of Justice considered, in addition to the normative provisions, constitutional principles, especially that of human dignity, but considered in a practical way, taking into account the existing limitations for the operation of implementing rights. It is verified, therefore, that the lack of an engine room aligned with the structuring constitutional

principles not only makes the effectiveness of rights unfeasible, but can also convert normative measures favorable to the enjoyment of rights and guarantees by the vulnerable into potentially harmful measures for this group, which, in the case of autonomy without consideration, can culminate in the increase of the vulnerabilities of the subjects.

Studies carried out and discussed within the scope of the federal legislative houses already demonstrate the impact of the dissonance between the rules and the engine room for the care and monitoring of the vulnerable. In this sense, the text of the Center for Studies and Research of the Legislative Consultancy of the Federal Senate (Oliveira, 2025) stands out, which addresses the practical difficulties related to curatorship, especially in relation to all the formal requirements that must be fulfilled, culminating in the perception that "no one wants to take over anyone's guardianship", due to the normative focus on formal elements, not in the material aspects inherent to this institute.

According to current rules, even if the curatorship takes place in family environments and with demonstrations of care and dedication in relation to the curator, the formal elements related to accountability stand out from the material criteria for verifying the curatorship (Oliveira, 2025), impairing the verification of the real interest of the curators.

As a result of this growing perception of a normative framework that is harmful to the vulnerable, beyond the mere ineffectiveness of the norms, proposals have emerged related to the reduction of the autonomy of the vulnerable, especially people with disabilities.

The apex of this issue lies in the recent discussions for the amendment of the Civil Code, consolidated in Bill No. 04/2025. Based on the assumption that the normative changes that have occurred since 2015 have been innocuous in practical terms, even harming the vulnerable in some cases, the normative proposal once again considers people with disabilities as absolutely incapable. In fact, the diagnosis is not wrong in relation to the effects of the changes, but it also does not consider the fact that more general actions were not taken to change the engine room of the constitution, which involves all the political, legal and institutional aspects that must be achieved in the protection of the vulnerable.

The justification of the bill is clarifying in this sense, as it makes clear the reasons for the amendment of articles 3 and 4 of the Civil Code, which reverberate in the other proposed changes. Literally, *"Another issue that required reflection and action concerns the changes in articles 3 and 4, **which recovered the protection** intended for those who are not in a position to express their will"* (Senado Federal, 2025. Italics). As can be read, the legislative discussions seek *to recover the protection* of vulnerable groups; that is, the normative changes under discussion are based on the assumption that the vulnerable were left helpless during the

changes in the Civil Code and the Code of Civil Procedure, showing, to some extent, the return of a paternalistic conception of the vulnerable in the scope of Brazilian civil law.

The legislative discussion, although well-intentioned, focuses on the consequences related to the problems existing in the engine room of the constitution in relation to vulnerable groups, and not on the causes of these problems, which consist of the forms of interaction with these groups in all social spheres. Thus, instead of equating the elements of private autonomy and the protection of the vulnerable, the legislator goes from one extreme to the other, without actually solving the matter.

Especially in the solutions related to vulnerable groups, especially protected by the Federal Constitution of 1988, the solution necessarily involves focusing on the existing performance and actions within the scope of the engine room. Any discussion or action that aims to solve the apparent dilemma between autonomy and protection of vulnerable groups must take into account that society itself still has a paternalistic conception (Gama; Bridges; Teixeira, 2014). For real progress to occur, the elements of equality established in the Constitution must consider all aspects of the individuality of subjects, regardless of their classification into categories, both in the public and private spheres (Fineman, 2008).

For these reasons, effective solutions must consider broader aspects in the relationship with vulnerable groups, recognizing the role of the engine room for the realization of rights, specifically with regard to power structures and the social, political, legal and administrative relations where rights are realized, considering that autonomy is not an inherent characteristic of human beings. but rather a product, a consequence, of social policies (Fineman, 2008).

In a practical way, material and discernment support must be given to families, who are primarily responsible for the care and emancipation of the vulnerable. In addition, legal culture should be seen as an axial requirement for the recognition and availability of rights, especially from the performance of lawyers, given that they are on the front line of protection (Klare, 1998), especially in cases of curatorship and judicial intervention; The role of judges also becomes central, given that a broader perception of judicial performance must be taken into account, both in structural cases and for decisions in the specific case.

Otherwise, normative changes will be doomed to become ineffective propositions or, in a more critical scenario, may be transfigured into mechanisms of unprotection or undue mitigation of vulnerable groups.

4 CONCLUSION

The solutions discussed for the adequacy of the rights of specially protected groups, under the terms of the Federal Constitution of 1988, have advanced in a non-linear manner over the last decades, revealing a gradual transition from a frankly paternalistic model to a format that recognizes, at least at the normative level, the full ownership of rights and the capacity for self-determination of these subjects. However, the analysis of the conformation of civil capacity after the Convention on Persons with Disabilities, the Statute of Persons with Disabilities and the 2015 Code of Civil Procedure, confronted with empirical data from the CNJ and the case law of the STJ, shows a relevant gap between the constitutional promise of autonomy and protection and the effective functioning of the engine room in which such rights should materialize.

From the perspective of transformative constitutionalism, it becomes clear that the non-paternalistic balance between autonomy and protection of vulnerable subjects cannot be achieved by mere punctual adjustments of the normative text, and it is imperative to construct structural criteria that guide the performance of the various actors located in the engine room, especially when bringing curatorship back to its truly exceptional and preferably patrimonial character; institutionalize practices of individualized assessment of capacities and needs; strengthen, in procedural and cultural terms, Supported Decision Making; and to develop jurisprudential parameters that articulate dignity, proportionality and relational autonomy in the definition of the degree of legitimate intervention in the existential sphere of the subject.

In this scenario, the reinforced protection of constitutionally protected groups must be reinterpreted as a duty to provide material, institutional and relational conditions for the exercise of autonomy, and not as a generic authorization to replace the will of the vulnerable with third parties, public or private.

In summary, the constitutionally adequate delimitation of the autonomy of vulnerable subjects, in the key of transformative constitutionalism, requires a shift of focus, leaving the abstract norm for the engine room in which this norm is concretized.

The challenge, therefore, goes beyond the choice between autonomy or protection, focusing on institutionally reconstructing the conditions in which reinforced protection becomes a materialization of rights, and not a denial of the capacity for self-determination of these subjects. Only from this structural reconfiguration, which involves legal culture, institutional arrangements and social policies, will it be possible to attenuate the apparent paradox between emancipation and tutelage, bringing legal practice closer to the constitutional project inaugurated in 1988.

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GEOPOLITICS OF FAITH AS A DEVICE OF POWER: RELIGIOUS INSTRUMENTALIZATION, CONFLICTS AND FORCED DISPLACEMENT IN THE CONTEMPORARY MIGRATION CRISIS

GEOPOLÍTICA DA FÉ COMO DISPOSITIVO DE PODER: INSTRUMENTALIZAÇÃO RELIGIOSA, CONFLITOS E DESLOCAMENTOS FORÇADOS NA CRISE MIGRATÓRIA CONTEMPORÂNEA

GEOPOLÍTICA DE LA FE COMO DISPOSITIVO DE PODER: INSTRUMENTALIZACIÓN RELIGIOSA, CONFLICTOS Y DESPLAZAMIENTOS FORZADOS EN LA CRISIS MIGRATORIA CONTEMPORÂNEA



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ABSTRACT

This study analyzes the geopolitics of faith based on the understanding of religion as a device of power in contemporary dynamics, investigating its instrumentalization in the production of geopolitical conflicts, social exclusions, and forced displacement. Situated within the fields of social sciences and international relations, the study examines how religious discourses and practices are mobilized by state actors, political agents, and armed groups as mechanisms for legitimizing violence, social control, and territorial reorganization on a global scale, with emphasis on the Middle East. The objective is to understand the role of faith in the production of exclusion, conflicts, and migration crises, as well as to analyze its impacts on contemporary geopolitical dynamics. To this end, a qualitative, exploratory, and bibliographic approach is adopted, based on academic literature, reports from international organizations, and institutional documents. Thus, it is observed that, although religion holds potential for social cohesion and solidarity, it has frequently been instrumentalized as a justification for persecution, human rights violations, and the intensification of conflicts, contributing to large-scale migratory flows. The findings indicate that religious instrumentalization constitutes a transnational and multifaceted phenomenon, with direct impacts on the reconfiguration of international relations and the expansion of humanitarian crises, requiring coordinated responses involving diplomatic actions, public policies, and international cooperation aimed at promoting human rights and building scenarios of peace.

Keywords: Geopolitics. Religious Instrumentalization. Forced Displacement. Human Rights. Power.

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RESUMO

O presente artigo analisa a geopolítica da fé a partir da compreensão da religião como dispositivo de poder nas dinâmicas contemporâneas, investigando sua instrumentalização na produção de conflitos geopolíticos, exclusões sociais e deslocamentos forçados. Inserido no campo das ciências sociais e das relações internacionais, o trabalho examina como discursos e práticas religiosas são mobilizados por atores estatais, políticos e grupos armados como mecanismos de legitimação da violência, controle social e reorganização territorial no cenário global, com ênfase no Oriente Médio. Objetiva-se compreender o papel da fé na produção de exclusões, conflitos e crises migratórias, bem como analisar seus impactos nas dinâmicas geopolíticas contemporâneas. Para tanto, procede-se a uma pesquisa qualitativa, de caráter exploratório e bibliográfico, fundamentada em literatura acadêmica, relatórios de organismos internacionais e documentos institucionais. Desse modo, observa-se que, embora a religião possua potencial de coesão social e solidariedade, tem sido frequentemente instrumentalizada como justificativa para perseguições, violações de direitos humanos e intensificação de conflitos, contribuindo para fluxos migratórios em larga escala. Os resultados indicam que a instrumentalização religiosa constitui um fenômeno transnacional e multifacetado, com impactos diretos na reconfiguração das relações internacionais e na ampliação das crises humanitárias, demandando respostas articuladas entre ações diplomáticas, políticas públicas e cooperação internacional, voltadas à promoção dos direitos humanos e à construção de cenários de paz.

Palavras-chave: Geopolítica. Instrumentalização Religiosa. Deslocamentos Forçados. Direitos Humanos. Poder.

RESUMEN

Este estudio analiza la geopolítica de la fe a partir de la comprensión de la religión como un dispositivo de poder en las dinámicas contemporáneas, investigando su instrumentalización en la producción de conflictos geopolíticos, exclusiones sociales y desplazamientos forzados. Enmarcado en el campo de las ciencias sociales y las relaciones internacionales, el trabajo examina cómo los discursos y prácticas religiosas son movilizados por actores estatales, políticos y grupos armados como mecanismos de legitimación de la violencia, control social y reorganización territorial en el escenario global, con énfasis en el Medio Oriente. El objetivo es comprender el papel de la fe en la producción de exclusión, conflictos y crisis migratorias, así como analizar sus impactos en las dinámicas geopolíticas contemporáneas. Para ello, se adopta una investigación cualitativa, de carácter exploratorio y bibliográfico, fundamentada en literatura académica, informes de organismos internacionales y documentos institucionales. De este modo, se observa que, aunque la religión posee potencial para la cohesión social y la solidaridad, ha sido frecuentemente instrumentalizada como justificación de persecuciones, violaciones de derechos humanos e intensificación de conflictos, contribuyendo a flujos migratorios a gran escala. Los resultados indican que la instrumentalización religiosa constituye un fenómeno transnacional y multifacético, con impactos directos en la reconfiguración de las relaciones internacionales y en la ampliación de las crisis humanitarias, lo que demanda respuestas articuladas entre acciones diplomáticas, políticas públicas y cooperación internacional orientadas a la promoción de los derechos humanos y la construcción de escenarios de paz.

Palabras clave: Geopolítica. Instrumentalización Religiosa. Desplazamientos Forçados. Derechos Humanos. Poder.

1 INTRODUCTION

The intensification of forced displacements in the contemporary scenario is intrinsically related to complex dynamics that articulate armed conflicts, territorial disputes, political crises, and identity tensions. In this context, forced migration should not be understood only as a consequence of conjunctural instabilities, but as an expression of power relations that operate in the production of vulnerabilities and the exclusion of certain social groups. Among these factors, the role of religion stands out, which, in addition to its cultural or spiritual dimension, has been mobilized as a power device capable of structuring political practices, legitimizing conflicts, and reconfiguring geopolitical relations on a global scale.

In recent decades, the instrumentalization of faith has been consolidated as a recurrent strategy in contexts of instability, being appropriated by States, political leaders and armed groups as a mechanism of social control and legitimization of violence. From this perspective, religion ceases to act exclusively as a space of symbolic belonging and begins to operate as a technology of power, producing identities, delimiting social boundaries and sustaining narratives of antagonism that reinforce political and territorial projects.

Data from the United Nations High Commissioner for Refugees (UNHCR, 2022) indicate that religious persecution and identity conflicts are among the main vectors of forced displacement on a global scale, contributing to the expansion of humanitarian crises and the significant growth in the number of refugees and internally displaced people. Such a scenario highlights the need to understand the relationship between faith, power and geopolitics as a structuring axis of contemporary dynamics of human mobility.

From a theoretical point of view, this study is based on the conception of religion as a device of power, understood as a heterogeneous set of practices, discourses and institutions that produce norms, regulate behaviors and legitimize relations of domination. From this perspective, according to Foucault (1979), power is exercised through discursive and institutional networks that produce subjects and organize social life. Thus, religion is analyzed as a strategic structure that crosses the political field, contributing to the production of conflicts, the exclusion of social groups and the intensification of forced displacements.

In view of this problem, the research is guided by the following questions: how faith has been mobilized as a mechanism of power in the legitimization of exclusionary practices and violence. And what are the impacts of this mobilization on geopolitical dynamics and migratory flows on a global scale. Based on these questions, the study aims to analyze the instrumentalization of religion as a power device in contemporary geopolitical dynamics, evidencing its effects on the production of conflicts, social exclusions and forced displacements.

In doing so, it seeks to contribute to the deepening of the academic debate on the relations between religion, power, and human mobility, highlighting the centrality of faith in the reconfiguration of the international system.

2 METHODOLOGICAL PROCEDURES

This study is characterized as a qualitative research, since it is dedicated to the interpretation of social, political and economic phenomena related to forced displacements in the context of the contemporary migration crisis. It is also an exploratory investigation, whose objective is to deepen the understanding of the relationships between geopolitical conflicts, instrumentalization of religion and human mobility, as discussed in the theoretical framework.

The research was conducted based on a literature review, understood as a fundamental procedure for the construction of the theoretical and analytical framework of the study. Such an approach allows us to critically examine the relations between religion, power, and forced displacement, based on academic productions, reports from international organizations, and institutional documents.

To this end, sources such as the United Nations High Commissioner for Refugees (UNHCR), the International Organization for Migration (IOM) and the World Bank are used in order to contextualize data, migratory trends and contemporary geopolitical dynamics. In addition, international treaties and legislation related to migration and human rights are analyzed, seeking to understand the role of the international community in the management of forced displacement.

This methodological approach makes it possible to articulate the theoretical assumptions, especially the understanding of religion as a device of power, with the analysis of empirical processes, contributing to a critical reading of the dynamics that structure the contemporary migratory crisis.

3 RELIGION AS AN INSTRUMENT OF POWER

3.1 FAITH AS A POLITICAL INSTRUMENT AND SOCIAL CONTROL

Throughout history, religion has played an ambivalent role in social and political conflicts, acting both as a cohesive force and as an element of legitimization of violence. In this context, its understanding as an instrument of power proves to be fundamental for the analysis of contemporary dynamics. As highlighted by Kofi Annan, former Secretary-General of the United Nations (UN), "some of the most heinous crimes in history were committed in the name of a

supposedly superior cause" (Annan, 2001), highlighting the risks associated with the instrumentalization of faith as a justification for practices of domination and exclusion.

Although religious principles, in their doctrinal basis, are often associated with values such as compassion, solidarity, and reconciliation, their strategic mobilization by political, state, and institutional actors can contribute to the legitimization of violent and exclusionary practices. In this sense, religion, as a device of power, operates in the production of discourses that define social norms and delimit boundaries between groups, directly influencing the organization of social and political relations.

Contemporary cases illustrate this dynamic. As international news reports and human rights reports indicate, countries such as Saudi Arabia have used religious grounds to justify practices such as repression of minorities, physical punishment, and restrictions on civil rights, often under the argument of maintaining moral order (Human Rights Watch, 2017; The Washington Post, 2015). Such practices show the articulation between religion and power in the legitimization of exclusionary policies.

The use of faith as a mechanism of social control is manifested through the production and dissemination of normative discourses that guide individual and collective behaviors. In many contexts, religious authorities exert significant influence in the construction of narratives that reinforce opposition between groups, contributing to the dissemination of discourses of intolerance and exclusion. Reports by Human Rights Watch (2017) show that in Saudi Arabia's education system, official content promotes discriminatory views towards religious minorities such as Shiites, Christians, and Jews, classifying them as "infidels" or "deviants." This discursive construction reinforces processes of social marginalization and legitimizes practices of institutional exclusion.

Religions, in general, structure normative systems based on moral and ethical codes, often based on texts considered sacred, such as the Bible and the Quran. These references, over time, influence not only religious practices, but also the social and legal organization of different societies. Historically, the articulation between religion and power has contributed to the consolidation of social norms, including the definition of gender roles and family structures. However, the internalization of these values occurs in a complex way, being mediated by socialization processes that involve family, community and religious institutions. The problem arises when such principles are mobilized in an imposing and excluding way, especially by fundamentalist groups, which seek to establish absolute truths and promote radicalization processes.

In contemporary times, the instrumentalization of religion by governments, political groups and extremist organizations shows its strategic potential in the legitimization of actions and in the exercise of social control. Faith, in this context, also operates through symbolic mechanisms of reward and punishment, such as promises of salvation or threats of condemnation, reinforcing adherence to norms and values. In addition, religion plays a central role in building social cohesion and collective identity, by promoting the sharing of beliefs, rituals, and symbols. However, this same process can contribute to the formation of rigid social boundaries, based on the distinction between "us" and "them", often mobilized in contexts of geopolitical conflict, ethnic rivalries and community tensions (Castro, 2012).

In summary, religion is configured as a structuring element of contemporary social dynamics, acting simultaneously as a source of meaning and as an instrument of power. Its capacity for symbolic and social mobilization allows both the promotion of humanitarian actions and the legitimization of conflicts, evidencing its relevance in political disputes and in the transformations of the international system.

3.2 RELIGIOUS EXCLUSION AND IDENTITY CONFLICTS

Religious exclusion is one of the most forceful expressions of the instrumentalization of faith as a device of power, operating in the production of social hierarchies, in the delimitation of belongings, and in the legitimization of practices of violence and control. More than an isolated phenomenon, it is a structuring mechanism of contemporary dynamics of conflict, in which religion is mobilized as a political language capable of defining who can or cannot occupy certain social spaces.

Recent data reinforce this centrality. A study by the independent human rights organization focused on Saudi Arabia (ALQST for Human Rights), based on information from the UNHCR, points out that 46% of Saudi citizens who requested asylum between 2023 and 2024 did so for reasons related to religious repression. Such evidence reveals that the denial of freedom of belief not only restricts individual rights, but also acts as a structuring factor in contemporary migratory flows. In this sense, forced migration is no longer understood only as a consequence of armed conflicts, but is analyzed as a product of power devices that operate in the systematic exclusion of subjects.

From the Foucaultian perspective, this dynamic can be interpreted as part of a regime of truth in which religious discourses are mobilized to produce and legitimize social norms. As Foucault (1979) points out, power is exercised through networks that produce subjects and regulate behaviors, which allows us to understand how institutionalized religious practices can

function as technologies of social control. Thus, religious repression is not limited to the prohibition of beliefs, but involves the production of subjectivities adjusted to the norms imposed by political-religious structures. This logic is particularly evident in authoritarian regimes, in which religious dissent is interpreted as a threat to the state order.

According to reports by Human Rights Watch (2023), countries such as Iran, China, and North Korea use religion as an instrument of surveillance and repression, setting strict limits on freedom of expression and belief. In these contexts, the control of the religious field acts as an extension of political power, evidencing the fusion between state authority and moral normativity. This interpretation dialogues directly with the contributions of Talal Asad (2003), when he argues that religion, far from constituting an autonomous sphere, is deeply imbricated in historical power relations. For the author, religious discourses are shaped by specific political contexts, and are often used to sustain projects of domination and exclusion. Thus, religion not only reflects social reality, but actively participates in its production.

In addition to internal control, the instrumentalization of religion is also manifested in the intensification of geopolitical conflicts, especially when associated with the construction of antagonistic collective identities. In the case of Yemen, for example, the division between Shiite and Sunni groups goes beyond the theological dimension, being mobilized as a legitimizing element of political alliances and military interventions. In this scenario, religion functions as a language of war, giving moral meaning to violence and hindering processes of mediation and conflict resolution (Armstrong, 2001). This dynamic shows that contemporary conflicts cannot be understood only from territorial or economic disputes, but must also be analyzed as symbolic disputes, in which religious identities are mobilized to produce differentiation, exclusion, and antagonism. As a consequence, entire populations are subjected to contexts of prolonged instability, resulting in large-scale forced displacement.

In Sudan, for example, the articulation between religious, ethnic, and political factors has contributed to the perpetuation of cycles of violence, highlighting the complexity of contemporary conflicts. These scenarios reinforce the idea that the instrumentalization of faith not only intensifies violence, but also compromises the conditions of social and economic stability, increasing the vulnerability of already marginalized groups.

Data from the UNHCR Global Trends report (2023), which points to more than 110 million displaced people in the world, show the magnitude of this crisis. In this context, religion emerges as a central element in the understanding of contemporary migratory flows, not only as a cultural factor, but as a political device that structures processes of exclusion and displacement.

Thus, religious exclusion must be understood as a multidimensional phenomenon, articulated with power dynamics that operate in the production of subjects, in the legitimization of violence and in the reorganization of geopolitical space. Such an approach allows us to overcome superficial analyses and understand the contemporary migration crisis as a result of structural processes deeply rooted in the relations between religion, power and identity.

4 CONFLICTS, PERSECUTIONS, FORCED DISPLACEMENTS AND MIGRATION CRISIS

4.1 SOCIO-POLITICAL CHALLENGES OF CONTEMPORARY MIGRATION

In the contemporary scenario, migratory flows have shown significant growth, driven by multiple structural factors, such as armed conflicts, ethnic-religious persecutions, socioeconomic crises, climate change, and environmental disasters. However, beyond their quantitative dimension, such displacements must be understood as the result of power dynamics that operate in the production of vulnerabilities and in the exclusion of certain social groups.

In this sense, the contemporary migratory crisis is not only configured as a consequence of conjunctural instabilities, but as an expression of broader historical and political processes, in which the instrumentalization of religion, as discussed in the previous sections, plays an important role in the legitimization of conflicts and the production of forced displacements. Thus, migration emerges as a phenomenon intrinsically linked to geopolitical disputes and strategies of social control.

The intensification of large-scale migratory flows imposes significant challenges on contemporary societies, especially in destination countries, where the arrival of vulnerable population contingents tends to put pressure on essential public systems, such as health, education, housing, and sanitation, as they claim (Verme; Schuettler, 2019). However, such impacts should not be analyzed in isolation, but understood within social and institutional structures previously marked by inequalities.

From this perspective, migration does not in itself constitute the origin of social tensions, but acts as a catalyst for pre-existing fragilities. As they point out (Castles; De Haas; Miller, 2014), the presence of migrants can be perceived as a threat to cultural cohesion, especially in contexts where national identities are constructed in an exclusionary way. This perception, often fueled by political and media discourses, contributes to the spread of xenophobic practices, discrimination, and violence.

The absence of effective public integration policies intensifies this scenario, favoring processes of social exclusion and socio-spatial segregation. UNHCR reports (2023) indicate

the growth of manifestations of intolerance against refugees, especially in European countries, associated with the rise of far-right political movements that instrumentalize migration as an element of ideological mobilization.

4.2 ECONOMIC AND GEOPOLITICAL DIMENSIONS OF THE CONTEMPORARY MIGRATION CRISIS

From an economic point of view, the impacts of migration are ambivalent. On the one hand, as the World Bank (2022) highlights, "well-managed migration can benefit both countries of origin and destination", contributing to economic dynamism, workforce renewal, and demographic balance. On the other hand, when it occurs in a disorderly way, it can intensify disputes for resources, put pressure on public services, and expand perceptions of socioeconomic insecurity.

This ambivalence shows that the effects of migration depend, to a large extent, on the structural conditions and governance strategies adopted by States. Countries such as Italy, Greece and Turkey, for example, when facing intense migratory flows in contexts of economic fragility, experience increased social tensions, reflecting the difficulty of articulating migratory policies and institutional capacities.

In the Global South, such challenges take on even more complex contours. In contexts marked by historical inequalities and institutional limitations, inadequate management of migratory flows tends to reinforce discourses of scarcity and competition for resources, in which migrants are often represented as threats to local populations (World Bank, 2022). This discursive construction, in line with the Foucaultian perspective, can be understood as part of a regime of truth that produces and legitimizes specific forms of exclusion.

Thus, the contemporary migration crisis must be analyzed as a multidimensional phenomenon, in which economic, political, and cultural factors are articulated with power devices that operate in the production of inequalities and in the regulation of human mobility. Migration, in this context, is not only a movement of physical displacement, but an expression of the power relations that structure the international system.

5 RELIGION, GEOPOLITICS, REPRESSIONS AND CONTEMPORARY SCENARIOS

5.1 DYNAMICS OF EXCLUSION AND POLITICAL LEGITIMATION BY RELIGION

In the contemporary context, even in the face of the secularization processes observed in various societies, religion remains a strategic element in power dynamics and international relations. Its presence in the geopolitical field evidences not only the permanence of traditional

structures of authority, but also the reconfiguration of mechanisms of control, exclusion, and political legitimization in a global system marked by interdependence and the intensification of conflicts.

From this perspective, religion should be understood not only as a cultural or spiritual dimension, but as a power device that operates in the production of discourses, in the construction of identities and in the organization of geopolitical relations, as discussed throughout chapter 3. Its instrumentalization by States and political actors reveals the centrality of faith in the configuration of contemporary scenarios of conflict and cooperation.

In the geopolitical field, the instrumentalization of religion is configured as a recurrent strategy of political legitimization and consolidation of collective identities. By mobilizing symbolic elements of faith, States and political groups produce narratives that delimit boundaries between belonging and exclusion, structuring the opposition between an "us" and an "other".

This process can be understood in the light of the concept of symbolic borders, developed by Lamont (2015), which refers to the social mechanisms of distinction and categorization between groups. In the international context, such borders are often constructed on the basis of religious, cultural and ideological differences, and are mobilized to reinforce internal cohesion and justify external policies.

Religion can act as a resource for political mobilization, especially in contexts of instability, in which collective identities are instrumentalized to legitimize conflicts and practices of violence (Brubaker, 2015). In this sense, faith ceases to be just an expression of belief to assume a strategic function in the production of antagonisms and in the definition of geopolitical alliances.

This dynamic is particularly evident in regions such as the Middle East, where tensions between Sunnis and Shiites transcend the religious field, articulating themselves with political, territorial and economic disputes. Thus, religion operates as a political language that confers moral legitimacy to state action and violence, reinforcing polarizations and hindering mediation processes.

5.2 THE INFLUENCE OF RELIGION ON INTERNATIONAL RELATIONS

Although religion plays an important role in several contemporary conflicts, its performance must be analyzed in conjunction with political, economic, and strategic factors. In this sense, the religious dimension is not an isolated cause, but is part of a complex set of elements that structure international relations.

The civil war in Syria exemplifies this complexity, as sectarian tensions intertwine with regional and global geopolitical interests, resulting in a multifaceted conflict (United Nations Country Team, 2024). Religion, in this context, acts simultaneously as an element of identity mobilization and as a discursive justification for political and military interventions.

The instrumentalization of faith also reveals contradictions in the foreign policies of states, especially with regard to the promotion of values such as human rights, democracy and religious freedom. The coexistence between universalist normative discourses and practices guided by strategic interests is often observed, evidencing the selectivity of international action.

In this scenario, the so-called religious diplomacy emerges as an ambivalent field: at the same time that it can favor intercultural dialogue and conflict mediation, it can also be used as an instrument of political influence and the reproduction of power asymmetries in the international system.

5.3 FAITH AND THE REDRAWING OF POLITICAL AND DIPLOMATIC BOUNDARIES

Beyond symbolic borders, religion also exerts influence on the configuration of territorial borders and the reorganization of geopolitical space. In various historical contexts, religious criteria were mobilized in the delimitation of states and territories, contributing to the consolidation of political identities and the emergence of lasting conflicts.

The partition of the Indian subcontinent in 1947 is an emblematic example of this process. The creation of India and Pakistan on the basis of distinct religious identities resulted in mass forced displacement and episodes of extreme violence, the repercussions of which remain to this day (Al Jazeera, 2017; Britannica, 2025). In this case, religion acted as an organizing principle of the political space, evidencing its centrality in the definition of borders and belongings.

Another significant example is Jerusalem, where religious, political, and territorial dimensions overlap intensely. The city, considered sacred by different religious traditions, is one of the main sources of tension in the Israeli-Palestinian conflict. The dispute for its control highlights how religion can be mobilized to legitimize territorial claims and reinforce collective identities in contexts of prolonged conflict.

In the context of globalization, the expanded circulation of people, ideas and beliefs intensifies both the possibilities for interreligious dialogue and the conflicts of values. Multicultural societies face the challenge of mediating religious differences in contexts marked by inequalities and identity tensions, requiring new forms of governance and social coexistence.

In this scenario, religion reveals its ambivalent character: at the same time that it can foster exclusions and conflicts, it also plays an important role in the promotion of humanitarian actions and international cooperation initiatives. Faith-based organizations have played a significant role in supporting migrants and refugees, offering material and symbolic assistance in different regions of the world (UNHCR, 2025).

Finally, the relationship between religion and forced displacement highlights the complexity of contemporary dynamics. Religious conflicts, persecution and sectarian tensions continue to drive migration flows on a global scale, while religious actors actively participate in humanitarian responses to these crises. Such duality reinforces the need to understand religion as a central element in the geopolitical and migratory dynamics of the twenty-first century.

6 FINAL CONSIDERATIONS

The present study sought to understand how religion has been instrumentalized in contemporary political and geopolitical dynamics, evidencing its role as a power device in the production of conflicts, social exclusions and forced displacements. It was based on the assumption that, although faith is historically associated with values of solidarity, belonging and social cohesion, its strategic mobilization by state, political and institutional actors inserts it in circuits of power that produce hierarchies, legitimize violence and reconfigure social and territorial spaces.

Throughout the analysis, it was found that religion plays an ambivalent role: at the same time that it strengthens collective identities and promotes social bonds, it can also be instrumentalized to establish symbolic boundaries between groups, reinforcing dynamics of exclusion and antagonism. This process, in line with the theoretical framework adopted, shows that faith should not be understood only as an individual or spiritual experience, but as a structuring element of the power relations that cross the social and political field.

With regard to the dynamics of conflict and human mobility, it was found that religious instrumentalization directly contributes to the intensification of persecutions, wars and humanitarian crises. The data analyzed demonstrate that the violation of religious freedom is a relevant factor in the production of forced displacements, evidencing the intersection between faith, human rights and international migration. In this sense, the contemporary migration crisis must be understood not only as a demographic phenomenon, but as an expression of structural processes of exclusion and violence.

The analysis also showed that religion goes beyond the internal scope of States, projecting itself significantly in international relations. Its role in the construction of identities, the

legitimization of alliances and the definition of territorial borders reinforces its role in the reconfiguration of the international system. Thus, the geopolitics of faith reveals itself as a central element for understanding contemporary conflicts and power dynamics on a global scale.

From a theoretical point of view, the study contributes to the broadening of discussions on religion in the social sciences and international relations, by evidencing its permanence as a strategic, and not a residual, dimension of contemporary political disputes. Such an approach reinforces the need for analyses that consider faith in its historical, symbolic and political dimensions, articulating it with the processes of power production and exclusion.

On the practical level, the results point to the urgency of public policies and international strategies that address not only the humanitarian consequences of forced displacement, but also their structural causes. This entails recognizing the role of religion in legitimizing conflicts and developing mechanisms that promote religious freedom, intercultural mediation, and the protection of human rights.

It is important to highlight, however, the ambivalent character of religion. If, on the one hand, it can be mobilized as an instrument of domination and exclusion, on the other hand, it also constitutes a space of solidarity, mediation and reconstruction of social bonds. The role of religious organizations in humanitarian actions shows their potential in promoting reception and international cooperation, especially in crisis contexts.

In summary, the instrumentalization of religion is configured as a multifaceted phenomenon, the understanding of which is essential for the analysis of contemporary dynamics of conflict, power and human mobility. The evidence presented allows us to affirm that faith, when politically appropriated, can intensify processes of exclusion and displacement, but also, when mobilized in its ethical and humanitarian dimension, contribute to the construction of paths of dialogue and reconciliation.

Finally, this study is not exhaustive in itself, but opens possibilities for future investigations, especially with regard to the role of transnational religious actors, the relationship between religion and global governance, and strategies for promoting peace in multicultural contexts. Given the complexity of the phenomenon, it is essential to expand comparative and interdisciplinary approaches, capable of deepening the understanding of the multiple articulations between faith, power and geopolitics in the contemporary world.

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GUARANTEEING THE RIGHT TO ADEQUATE SCHOOL MEALS FOR STUDENTS WITH SPECIFIC DIETARY NEEDS: CHALLENGES, UPDATES, AND RECOMMENDATIONS FOR MUNICIPALITIES

GARANTIA DO DIREITO À ALIMENTAÇÃO ESCOLAR ADEQUADA DOS ESTUDANTES COM NECESSIDADES ALIMENTARES ESPECÍFICAS: DESAFIOS, ATUALIZAÇÕES E RECOMENDAÇÕES AOS MUNICÍPIOS

GARANTÍA DEL DERECHO A UNA ALIMENTACIÓN ESCOLAR ADECUADA PARA ESTUDIANTES CON NECESIDADES ALIMENTARIAS ESPECÍFICAS: DESAFÍOS, ACTUALIZACIONES Y RECOMENDACIONES PARA LOS MUNICIPIOS



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ABSTRACT

This study aims to describe the challenges related to access to the right to health for students with special dietary needs within municipalities and in the preparation of school menus. This is an article systematized through the experience of nutritionists regarding the challenges faced in guaranteeing the Human Right to Adequate Food (HRAF) for children and adolescents with allergies, food intolerances, and/or celiac disease. The results showed that, despite the exclusion of certain foods and the development of specific menus to meet the needs of students with specific dietary requirements, significant challenges remain. Our intention is to contribute to reflections on the issue of students' citizenship rights and on the importance of control, monitoring, and enforceability mechanisms to ensure these rights. This experience may serve as a stimulus for the development of child protection mechanisms, as well as for the promotion, prevention, and precautionary protection of children's health in educational institutions, in addition to ensuring universal access to education.

Keywords: Human Rights. Health Promotion. Child Protection. Education.

RESUMO

Este estudo tem por objetivo descrever desafios do acesso ao direito à saúde dos estudantes com necessidades alimentares especiais nos âmbitos dos municípios e da produção dos cardápios. Trata-se de artigo sistematizado por meio da vivência das nutricionistas sobre os desafios enfrentados para a garantia do Direito Humano à Alimentação Adequada (DHAA) para crianças e adolescentes com alergias, intolerâncias alimentares e ou celíacos. Como resultados, o estudo apontou que apesar da exclusão dos alimentos e cardápios específicos

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para o atendimento dos alunos com necessidades alimentares específicas. Nossa intenção é contribuir para a reflexão sobre a temática dos direitos de cidadania dos estudantes e sobre a importância do controle, monitoramento e exigibilidade para poder garanti-los. Esta experiência pode ser um estímulo para a construção dos mecanismos de proteção da criança, e da promoção, prevenção e precaução da saúde da criança em instituições de ensino, assim como para a garantia da universalização do acesso à educação.

Palavras-chave: Direitos Humanos. Promoção da Saúde. Proteção da Infância. Educação.

RESUMEN

Este estudio tiene como objetivo describir los desafíos relacionados con el acceso al derecho a la salud de los estudiantes con necesidades alimentarias especiales en el ámbito de los municipios y en la elaboración de los menús escolares. Se trata de un artículo sistematizado a partir de la experiencia de nutricionistas sobre los desafíos enfrentados para garantizar el Derecho Humano a la Alimentación Adecuada (DHAA) para niños, niñas y adolescentes con alergias, intolerancias alimentarias y/o enfermedad celíaca. Como resultados, el estudio señaló que, a pesar de la exclusión de ciertos alimentos y de la elaboración de menús específicos para atender a los estudiantes con necesidades alimentarias específicas, aún persisten importantes desafíos. Nuestra intención es contribuir a la reflexión sobre la temática de los derechos de ciudadanía de los estudiantes y sobre la importancia del control, monitoreo y exigibilidad para garantizar dichos derechos. Esta experiencia puede servir de estímulo para la construcción de mecanismos de protección infantil, así como para la promoción, prevención y precaución de la salud de niños y niñas en instituciones educativas, además de garantizar la universalización del acceso a la educación.

Palabras clave: Derechos Humanos. Promoción de la Salud. Protección de la Infancia. Educación.

1 INTRODUCTION

The right to education does not differ from the right to life. The right to education does not diverge from the right to food. Access to education cannot be hindered by the lack of adequate food. After all, keeping children protected is also about education. This text synthesizes mishaps from the field to the school feeding table. We know that there are many successes, but here we will focus on the weaknesses, diversities and inequalities of a certain public that still has difficulties in this access: children and adolescents with special dietary needs.

The Universal Declaration of Human Rights states in its article No. 25 that every human being has the right to a standard of living that ensures health, well-being and food. Human Rights are considered natural rights, as they are directly related to the dignity of human nature. They do not need to be specified in a law to be demanded, recognized, protected and promoted and represent the indispensable conditions for all human beings to exist, develop their capacities and integrate into life in society in a fair and inclusive way, being respected in their individualities. In addition, human rights are inalienable, non-transferable, non-negotiable and unavailable, which means that they cannot be voluntarily ceded by anyone, nor can their realization be subject to conditions (Benevides, 2013; CONSEA 2006).

In this perspective, as a result of a process of collective construction and with social participation, the Organic Law of Food and Nutrition Security (LOSAN) was created in 2006, creating the National Food and Nutrition Security System – SISAN with the objective of ensuring the human right to adequate food (DHAA). This fact was important for the constitutional recognition of the DHAA in 2010, and to guide actions for its realization, both in relation to the role of the State as guarantor of the right, and of civil society in the role of demanding and monitoring its implementation (Brasil, 2006; IFZ, 2022).

Therefore, the right to adequate food is at the basis of other human rights and also because it involves food sovereignty and security and an imperative of citizenship. An imperative of citizenship because it involves some facets such as the principle of Safety and Responsibility, the principle of preservation of life and human health, the principle of health protection, conservation of the environment, the principle of prevention and precaution, the principle of transparency, the principle of consumer interest combined with the principle of regulation of products and processes, and the principle of sharing criminal and civil responsibility (Frota, 2011).

In this text we will highlight the challenges for the realization of the right to serve the most vulnerable public with regard to the universalization of access to School Feeding, emphasizing

how fundamental it is that the Entities and units executing School Feeding understand the construction of the right and the challenges for its implementation. In addition, they must perceive and wish to implement a training process to know the differences and carry out risk analyses for each metabolic and physiological alteration of those enrolled. And so they can understand that caring for diabetic children is different from caring for obese children. Serving children with food selectivity and malnutrition is different from attending children with phenylketonuria. And serving children with food intolerances is different from treating allergy sufferers and celiacs. And that they also understand that the processes of risk analysis and the construction of good practices to produce safe food involve monitoring the entire production chain from field to table (Brasil, MEC/FNDE, 2016). Thus, this study aims to present the mechanisms of care management for students who have specific dietary needs in Marechal Cândido Rondon, state of Paraná, presenting the results achieved by the municipality, its challenges and difficulties for the implementation of the law and consequent guarantee of the DHAA of students enrolled in schools and Early Childhood Education centers in the municipality.

2 THEORETICAL FRAMEWORK

Over time, the creation of legal, programmatic, budgetary and participatory guarantees for the DHAA has been fundamental. However, there are still great challenges to be overcome for its implementation, especially when it is realized that in addition to hunger, other food inadequacies must be recognized as a form of violence against human beings and violation of the right to life, and that it is the State's obligation to make these rights effective, creating and organizing the means, institutions, services, and public policies so that citizens can access these rights without interruptions, making social protection effective (Guerra, 2022; Mendes and Preuss, 2024). Whereas the violation of a right is:

any action by the State or third parties to disrespect, infringe, prevent, transgress, violate, embarrass, take, steal or threaten the rights that are guaranteed by national and international laws (Brasil, 2017a, p.10)

It is therefore essential that rightholders know what they are and take ownership of their rights, that they are informed about how they can enforce them and what instruments are available for enforceability. It is necessary to create routines and public instruments for the collection of rights, first of all in the administrative sphere, starting with the local and municipal level of easy public access, and close to the communities. In addition, managers and public servants must be trained on the obligations that fall to them as agents of the State in the

realization of human rights. In the case of the enforceability of rights, access to information about rights for citizens, and about obligations for public agents, is essential. The enforceability mechanisms must be available in all instances and spheres of the Executive, Legislative and Judicial Branches. Among the institutions currently available in Brazil are the Public Prosecutor's Office, the Public Defender's Office, the Human Rights Councils and the Public Policy Councils.

It is essential to know that the DHAA has two indivisible dimensions: the right to be free from hunger and malnutrition and the right to adequate food, and its guarantee requires the guarantee of all other human rights, especially the human right to health (Burity *et al*, 2010). It is essential that the State act legally to prevent the violation of the DHAA and create public policies that guarantee this right.

To this end, in the field of health, several documents deal with the importance of promoting and preventing health problems and point to the need to formulate and implement effective and integrated national, local and regional strategies to reduce morbidity and mortality related to inadequate nutrition. Among these actions and policies that have a regulatory, fiscal and legislative character, the National Food and Nutrition Policy (PNAN), which has among its guidelines, the Promotion of Adequate and Healthy Food (PAAS), as being the promotion of a food practice appropriate to the biological and sociocultural aspects of individuals and the sustainable use of the environment and that:

it must be in accordance with the needs of each stage of the life course and with special dietary needs; referenced by food culture and by the dimensions of gender, race and ethnicity; physically and financially accessible; harmonic in quantity and quality; based on adequate and sustainable production practices with minimal amounts of physical, chemical and biological contaminants (Brasil, 2017b, p.31)

Also noteworthy in the PNAN, the Organization of Nutritional Care, which "comprises care related to food and nutrition aimed at the promotion and protection of health, prevention, diagnosis and treatment of diseases" for all, with a view to the formation of an integrated, problem-solving and humanized care network, including care for individuals with special dietary needs, such as those resulting from inborn errors of metabolism, eating disorders, among others (Brasil, 2017b).

In view of this, it is verified that the perspectives of the PNAN are not limited to meeting the precepts of the Unified Health System (SUS), but seek to act in an intersectoral way so that the National System of Food and Nutrition Security (SISAN) is established and strengthened. In addition, it is observed that it is based on actions that consider the citizen in his totality, in his

individual and collective needs, and that resolute actions in these areas necessarily require partnerships with other sectors, such as Education. Intersectoriality forms shared decision-making spaces between institutions and different government sectors that should promote health and FNS through the formulation, implementation, and monitoring of public policies that positively impact the health of the population (Brasil, 2017b). In this way, it can be stated that in all spaces, including educational spaces such as schools and daycare centers, they should be built based on health promotion through access to adequate and healthy food.

Among these public policies that also aim at Food and Nutrition Security and health promotion, in the area of education, the National School Feeding Program (PNAE) stands out. César *et al* (2018) state that over time the PNAE stopped focusing exclusively on the state of hunger and expanded the service of students in the school period as a whole. This expansion extended to the incorporation of care for individuals collectively and individually, considering health conditions and aspects of socioeconomic, cultural and environmental sustainability.

In this perspective, in order to achieve the objective of the PNAE of "contributing to the growth and biopsychosocial development, learning, school performance and the formation of healthy eating practices of students", school feeding began to be offered based on legal guidelines and the principles and dimensions of the human right to adequate food (DHAA), reinforced with food and nutrition education actions and the provision of meals that meet the nutritional needs of students during the time they stay in the school space for at least 200 school days in a stable, regular and permanent manner (Brasil, 2009)

In addition, considering the universal attendance of the Program, there was the implementation of Law No. 12,982/2014, which sought to guarantee the DHAA in the school environment, ensuring individual care and offers of adequate and healthy food based on the biological conditions of students with special dietary needs (Brasil, 2014).

These special dietary needs (ANE) are defined by the PNAN as those identified through evidence of metabolic and physiological changes that require changes in the dietary requirements of individuals:

[...] or supplemental, of individuals with metabolic or physiological alterations that cause changes, temporary or permanent, related to the biological use of nutrients or the route of food consumption (enteral or parenteral). Examples: inborn errors of metabolism, celiac disease, HIV/AIDS, food intolerances, food allergies, eating disorders, prematurity, nephropathies, etc. (Brasil, 2017b, p.74).

Although currently the inclusion of children with special dietary needs in school is not questioned as a right, it can be said that its operationalization was late, as it was observed that

throughout the twentieth century, the recommendation of health professionals towards children with specific dietary needs was for them to be homeschooled, at least until they needed to learn to read and write. There was no protection mechanism guaranteed by law. Although the Federal Constitution of 1988 guaranteed the right to Education and LDBEN 9394/96 materialized the challenges for all, even so, school feeding did not operate with diversity, after all, the right to food was only included in the Constitution in 2010. And many times, children with specific dietary needs, even when they started to be enrolled, continued to be invisible, unknown, kept in a state of vulnerability and not heard (Paula, 2016).

With this focus, in 2014, Law No. 12,982 was created in 2014, which made individualized nutritional care mandatory in case of specific state or health condition, with the elaboration of a special menu based on medical and nutritional recommendations, nutritional assessment and differentiated nutritional demands of students (Brasil, 2014).

This law came to meet a growing and alarming need shown by several studies that attest to an increase in the prevalence of diseases associated with food and nutrition in the child population, imposing the need for continuous monitoring and evaluation of the PNAE, and the implementation of strategies and actions that promote the improvement of care and the planning of the nutrition and health policy of schoolchildren. ensuring the well-being and safety of children and those involved in the process. Considering the legal basis that supports the universal right to school meals, health promotion, and the DHAA, this scenario makes feeding in the school environment challenging due to the complexity of individual care and the legal basis that supports the universal right to school meals, health promotion, and the DHAA (Pereira *et al*, 2024).

In this way, the offer of special food to serve students with NAE is a right guaranteed by law, which aims to reduce the biological and social damage of this public, it is essential that there is an understanding that any person can file a complaint and demand the guarantee of the realization of their right, or a dimension of it, before administrative, political or judicial public bodies, "in order to prevent, overcome and/or repair violations". In addition, the population also has the right to have a response and action in a timely manner to repair the violation by the public authorities, considering that the obligations and responsibilities for the realization of this right are of the managers and public agents involved in the execution of the PNAE and it is the State's obligation to respect, protect, promote, and provide adequate food and nutrition, protecting students from any interference that may deprive them of access to adequate food at school (FIAN, 2021).

Also noteworthy, to guarantee this right, is the principle of universality of the PNAE, which will only be effective when all students can enjoy adequate and healthy school meals as their right. For this, it is necessary that, in addition to the State, other actors involved in the Program such as nutritionists, school feeding councils, parents, managers and teachers, and civil society recognize themselves as responsible for guaranteeing this right (César *et al*, 2020).

In addition, in order to ensure the adequate care proposed by the PNAE to students with NAE, it includes, in addition to the preparation of an adequate menu and the planning for their acquisition, the identification with the diagnosis for the monitoring of the nutritional status of these students. From the perspective of equality and equity in care, it should also contribute to ensuring that the student with NAE is ensured through comprehensive care from the perspective of the professional in charge, and other actors involved (Colares; Sorato, 2019).

It is essential to integrate the strategies and actions of the education, health and FNS teams, including training for the professionals involved; intensify the support between the multidisciplinary team of the basic health unit and the schools to develop care plans and emergency actions in cases of allergic reactions, anaphylaxis and aggravation of diseases diagnosed in schools. (Pereira *et al*, 2024)

Finally, when dealing more specifically with individual care for students who have special dietary needs in the school environment, it is essential that all those involved in the educational process are aware of the biological conditions involved, which physiological and metabolic aspects make this individual the bearer of a right to food that respects these conditions.

In this research, the conceptual basis of the pathologies that represent the greatest challenges in the execution to comply with the legislation was presented, which are food allergies and celiac disease. The challenges are greater because it is not only the nutrition professional who is involved, it is not only the exclusion of allergens, or wheat, rye and barley, in the case of celiacs. The difficulty of execution is because the small fraction of the protein can trigger reactions. It is due to the severity of the symptoms and health problems of these children. It is crucial that the school community knows about celiac disease and the specific dietary needs of students and how to avoid protein from the purchase of inputs but also from environmental contamination, direct contamination, cross-contamination or residues on utensils and surfaces. Security, inclusion, and transparent communication must be ensured. It is based on the ethics of care that "represents an attitude of occupation, concern, responsibility and involvement with the other" (Boff, 2014, p. 37).

An update of the guidelines takes place in 2026 with a new FNDE Resolution. Highlighting the service criteria.

Art. 5 The guidelines for school feeding are: I - the use of healthy and **adequate** food, including the use of varied, safe foods that respect the culture, traditions and healthy eating habits, contributing to the growth and development of students and to the improvement of school performance, in accordance with their age group **and their state of health, including those who need specific attention**; (Brazil, 2026, emphasis added)

Making the intention of service transparent:

VI – the right to school meals, in order to ensure the food and nutritional security of students, with equal access, **respecting the biological differences between ages and health conditions of students who need specific attention** and those who are socially vulnerable. (Brazil, 2026, art 5, emphasis added)

Regarding the construction of menus, the 2026 Resolution makes explicit:

School Feeding Menus Art. 17. School feeding menus must be prepared by the RT nutritionist of the PNAE, based on the use of fresh or minimally processed foods, in order to respect the nutritional needs, eating habits, food culture of the locality and be based on sustainability, seasonality, agricultural diversification of the region and the promotion of adequate and healthy food.

Paragraph 1 - The menus must be adapted to **meet the needs of students diagnosed with special dietary needs** and atypical eating behaviors, such as: **celiac disease**, diabetes, hypertension, anemia, **allergies**, food intolerances, food selectivity, among others.

2º Students with disabilities, global developmental disorders and with high abilities/giftedness must receive school meals during the schooling period and, at least, one meal in the after-hours, when in SEA, in **order to meet their nutritional needs, according to their specificities**. (Brazil, 2026, art 17, emphasis added)

It is worth noting that the groups in special food needs are not in alphabetical order and denote other priorities of the regulatory body for enforcement. This time, making explicit what is a diet that is appropriate to the biotype and productive of health.

3 PHYSIOLOGICAL AND METABOLIC CHARACTERISTICS OF STUDENTS WITH SPECIAL DIETARY NEEDS

3.1 FOOD ALLERGIES

Based on information provided by the Brazilian Consensus on Food Allergies (2018), food allergy is a public health problem, defined as a "disease resulting from an anomalous immune response, which occurs after ingestion and/or contact with certain food(s)". A food can cause allergic reactions in three ways: a) when the food is ingested or there is contact with the

skin or respiratory tract; b) when, through cross-reaction, there is the production of specific IgE and sensitization even before contact with the food, c) when there is cross-reactivity between an inhalable allergen (e.g. pollens, latex) responsible for sensitization and production of IgE and ingestion of the food. All foods can cause allergies, but approximately 80% of them are caused by the ingestion of cow's milk, eggs, soybeans, wheat, peanuts, nuts, fish and crustaceans (ASBAI, 2018a).

It is important to note that some foods cause cross-reactivity, causing a person allergic to a specific food to experience symptoms when consuming other foods that contain proteins with similar structures. An example of this is tropomyosin, which is present in different sources such as crustaceans, mollusks, mites and even plants, causing a person allergic to shrimp, for example, to also have a reaction when eating foods with the same protein (ASBAI, 2018a).

For the diagnosis, the clinical history is essential, which depends on the patients' ability to recall the symptoms, and the ability and sensitivity of the physician to correctly identify those who have the disease. Laboratory investigation may also be carried out (ASBAI, 2018b).

In the school environment, guidance should be given on the importance of monitoring by a doctor and nutritionist on a continuous basis, guidance and monitoring, which is also essential to: check if there is cross-reactivity with other foods, if the student has acquired any tolerance to the food and, also, to assess and monitor the general state of health and nutritional status, since this can be compromised by the manifestations of allergic reactions due to the exclusion diet. It is also important to verify the need for nutritional supplementation (Brasil, 2017).

As for the nutritional issues involved, so that there is no harm to the growth and development of students, it is proposed that the Food Allergy (AA) certificate should not be considered as a definitive condition, as the unnecessary continuous adoption of an exclusion diet can harm the student in the long term. It is also recommended that the main modification in the menu be the complete exclusion of food allergens and, in the case of infants, the use of expressed breast milk or adequate infant formulas, ensuring the nutritional supply of energy, macro and micronutrients.

3.2 CELIAC DISEASE

Although the prevalence of celiac condition is around 1/200 people, the diagnosis is still late and related to nutritional sequelae. Gluten-related disorders (GRD) affect 1% to 6% of the population, with complications and a high risk of morbidity and mortality in the short and long term (Cruscinsky, 2021). Even though there has been a Clinical Protocol and Therapeutic Guidelines (PCDT) since 2009, it is common for people to claim that health professionals are

unaware of the subject (Ministry of Health, 2009), and the common sense remains that it is a digestive gluten intolerance.

The celiac person lives with a systemic autoimmune condition that does not only affect the small intestine. It is a permanent whole-body reaction to gluten characterized by a systemic inflammatory process that also involves the mucosa of the small intestine, generating atrophy of the intestinal villi, malabsorption, and a variety of clinical manifestations (Araújo *et al*, 2022; Garcia *et al*, 2023). These are, within the scope of human diversity, people who, by genetic constitution, live with a permanent biological incompatibility with winter cereals, wheat, rye, barley and oats, especially with their protein called gluten. Gluten in celiacs will produce metabolic and physiological changes that can cause significant damage and aggravation to health. To survive, a consensus was reached that the daily life of the celiac person should be the exclusion of contact with gluten. From then on, attending to celiac children is to meet their special dietary needs, but also to practice celiac education so that they can interact with their peers. Therefore, it requires full attention and respect in the school environment in order to overcome social barriers.

In view of this, we reiterate that celiac is an autoimmune, permanent, self-destructive, non-transmissible condition, whose trigger is gluten in people with genetic predisposition. It is genetic, but not hereditary. These are not defective genes, but more likely to be a mark of shared ancestry with other primates. Having the genes is not enough to develop the autoimmune alteration, it can develop, or not, depending on exposure to the environment. But, in the school environment, it is common to ask: What complications or physiological and metabolic changes can be caused by non-attendance in the development of celiac students?

First of all, let's remember that the word celiac comes from the word colic and this already helps us to understand that this student has pain. Although it seems like a simple change in diet, daily life can be a constant challenge, with serious impacts on psychological health and emotional balance. (Bai, Ciacci, Corazza, 2016). Only a few celiacs will have dermatitis herpetiformis with visible lesions, most of the manifestations of Gluten-Related Disorders can be subjective: pain, malaise and tiredness. This makes it difficult to identify the severity of the symptoms and leads to the trivialization of complaints.

This reality has serious consequences for the health of these people, described in the PCDT (Ministry of Health, 2009, 2015) as digestive alterations (canker sores, esophagitis, stomatitis, duodenitis, liver alterations, diarrhea and severe colds), neurological and reproductive alterations and infertility, thyroid alterations, depression, anemia, joint pain, malabsorption of nutrients, weight loss, slow growth, osteoporosis of dental problems,

malnutrition and alterations pathological or lesions in organs or systems, capable of being seen or measured by exams, refractory celiac disease, cancer of the digestive system, lymphoma, and even sepsis.

Just as pain, often disabling and with great damage to quality of life, cannot be quantified. Currently, the status of celiac condition as a more acceptable gluten-related disorder is that of pathology. However, the community discusses other statuses, such as permanent physical disability and diverse human condition. Although these statuses are not convergent for the formulation of public policies and generate internal debates, they do not alter the material existence of the children and adolescents who need to be served.

It is worth mentioning that the education professional does not diagnose either food allergies or celiac allergies. These diagnoses follow exclusive PCDT. However, it is up to the education professional to report problems that occur with the child to the family members and guide the referral. Remembering that many municipalities have joined the Health at School Program.

4 INSTITUTIONAL AND INFRASTRUCTURE CONDITIONS TO GUARANTEE ACCESS ON A PERMANENT AND CONTINUOUS BASIS

The planning of the menus must follow the recommendations of the FNDE and serve students enrolled in the Municipal Center for Early Childhood Education (CMEI) full-time with 4 meals a day for children from 6 to 11 months and children from 1 to 4 years old. The nutritional value of these meals meets 70% of the students' daily nutritional needs. For students enrolled in Elementary 1 schools, the menus are prepared serving 01 daily meal, for children in the morning and afternoon periods enrolled. These students have at least 30% of their daily nutritional needs met.

According to legal guidance, NAE students are served with a specific menu for their needs. Nutritionists elaborate, in addition to the general menus, menus identified as: a) without milk. b) without egg; c) without wheat; d) without milk and without egg and without wheat; e) for diabetics. In case of other allergens such as soy, dye, oilseeds, honey, fruits, these foods are advised. One of the difficulties in executing differentiated menus is the purchase. After all, nutritionists often claim that the result was deserted.

Some municipalities in order to achieve the menus, purchase food via bidding by electronic auction, once a year, seeking to obtain food that meets all special dietary needs. However, other municipalities other purchasing processes are elaborated and the request for

the presentation of the product's technical sheet to ensure that it meets the NAE and, above all, does not pose a risk to the student, as stated in the FNDE reference booklet (Brazil, 2017).

To serve celiac students, rice-based and gluten-free foods are purchased, such as rice noodles, rice crackers, gluten-free bread, gluten-free oats and rice flour. For diabetics, artificial stevia sweetener, brown rice, whole wheat pasta, diet chocolate milk, sugar-free wholemeal biscuits are purchased and it is recommended to remove sugar in culinary preparations or replace it with fruit juices or raisins.

Among the guidelines for culinary preparations, substitutions are used, for allergens such as CMPA and allergy to egg protein, it is the removal of these foods in preparations and replace them according to guidelines, for example, in a cake preparation, milk is replaced by fruit juices or water and egg by vinegar or flaxseed. In addition, students with CMPA are purchased milk-free growth formulas (from 0 to 12 months), soy milk and vegetable yogurt, lactose intolerant products are purchased.

The request for specific school meals follows the protocol: families make the request at the school office or to the principal, attaching the related documentation and statements, and the school forwards it to the municipal school feeding service. Family members can access the menu that is available at educational institutions. Interviews and conversations are often necessary for service adjustments. The service process must comply with the recommendations of Resolution/CD/FNDE No. 06/2020 (which establishes that menus must meet students with specific nutritional needs) as well as that specified in Federal Law No. 12,982/14. Ribeiro *et al* (2014) considered that the mapping of students is the first step towards the implementation of strategies that aim to meet their needs.

In schools and CMEI's, at the time of enrollment, the declaration if the student has any NAE is requested and the statement of the health professional or medical report or nutritionist's report is also requested. This request is valid for one year and needs to be renewed, after all, the clinical condition may have evolutions and/or complications. Colares *et al* , in a study carried out with 134 school feeding nutritionists in Santa Catarina, pointed out that 85.9% (n=115) request the updating of supporting documents at least once a year. It is recommended that an identification of each student and their NAE be carried out in the school environment, to ensure their safety. This service protocol, which provides for the sending of a document by the school manager to the nutritionist, agrees with what Rosa, Pavão and Marquesan (2019) cite about the articulation between nutritionists and managers in the implementation of menus for students with NAE, considering that it is the principals who welcome these students.

From this perspective, the challenge is even greater when considering the care of students with Celiac disease, as one must be aware of the fact that when a food that is naturally gluten-free (fish, fruits and vegetables, meat, dairy products, seeds, eggs, nuts...) or that has been developed especially for celiacs (such as gluten-free bread), cross-contact or direct contact can occur, making the food unsafe for consumption. To this end, a Good Practices protocol and continuing education are required for the food handler to understand and perform the risk analysis. Contact with gluten can occur through a common surface, through residues in shared utensils, through shared equipment, or through the food handler who, when preparing food in a sequence, can transfer small pieces or particles of protein.

Thus, given the seriousness of the consequences of the violation of the student's right and knowing that food is the basis of treatment for celiac disease, with a strict gluten-free diet as the only effective treatment so far, are municipal managers and nutritionists attentive to fulfilling their responsibility? How can an understanding be reached that the guarantee of the DHAA of students with NAE would help in the process of promoting the health and quality of life of celiacs? How, in addition to taking care that those labeled as gluten-free, good handling practices, a menu that effectively offers nutrition and a gluten-free diet, that takes care of the risks of the presence of traces of this protein in other foods, that takes care of the environment where the food is stored, prepared and distributed, still guarantees food education? How to promote health and inclusion?

Safety in the management of care goes beyond nutritional issues and reaches the conditions of human resources and infrastructure. Training is carried out every six months with school cooks using theoretical and practical methods, every 6 months. How to manage the turnover of outsourced professionals? The theoretical part explains each type of NAE and what care should be taken with the preparation so that there is no cross-contamination, the hygiene of utensils, storage and storage of specific foods for these needs. The practice needs to address recipes that can be made with the ingredients purchased for these students and the substitutions for each NAE. On the part of the nutritionists in charge, it is also necessary to carry out technical visits weekly to ensure that this work is being done and for further guidance in case of doubts.

For nutritionists, training for food handlers is still insufficient, mainly due to the high turnover of the workforce, causing many professionals who participate in the first event to no longer be present at the second meeting. Also, due to the insecurity in the operationalization of the recommendations, which in the opinion of the nutritionists, may be the result of the low level of education of the professionals who prepare the food and the recognition of the great

responsibility with the health of the students in case there are failures in the care process. This fact does not agree with the study carried out by Souza and Nascimento (2019) who in a survey carried out with 06 nutritionists and 06 food handlers from two municipalities in Greater Florianópolis on the effectiveness of human resources training, and which showed that the former see that they carry out efficient training, and the handlers feel well guided and trained by nutritionists regarding pre-preparation, preparation, handling and storage of products and utensils, to avoid cross-contamination with gluten

A contradiction has been produced and needs to be better heard. Some municipalities prohibit students from bringing any food from home, due to biological risks and contamination. In other municipalities it is possible to bring only some type of fruit. In some prohibitions, there is a prohibition, both for socioeconomic factors and food security, for celebrating birthdays in schools. In other municipalities, they still authorize this practice by bringing into this environment external food without the certainty of the origin, without designation of the place where they were produced were adequate, or without the certainty of whether the handler maintained good hygiene practices, the quality of the ingredients, among others. Such a practice, in addition to producing a certain frustration in those who cannot enjoy collective food, leads to another question. Who sanitizes the school environment after the celebration and ensures the cleanliness of traces of proteins in the environment? Within this context, many municipalities have banned snacks brought from home. On the other hand, there is an increasing number of municipalities that, in municipal legislation, guarantee students with specific dietary needs to take their ready-to-eat food from home to school.

Even with the municipal provision legalized, such practice does not occur without conflicts, including legal ones, in the coexistence of different enforcement models. Below we will make a brief list: a) phenylketonuria students whose school meals are provided directly from the health department to the school and part of it is delivered to their families so that they can take fractional; b) celiac and allergic students who take all meals produced by family members to school in full with the recommendation that it be close to the menu, or not; c) municipalities that provide the families of celiac and allergic students with the ingredients d) municipalities that provide the families of celiac and allergic students with ingredients, lending equipment, gas, and containers for transportation to school; e) municipalities that offer a place for students to store their food brought from home and heat it; f) municipalities that produce specific foods in a central kitchen and distribute them to school units or family members.

5 DIFFICULTIES AND CHALLENGES OF ACHIEVING UNIVERSALIZATION OF STUDENT CARE WITH NAE

Another relevant issue is the vulnerability arising from a Special Food Need or a chronic disease that affects these students in different ways. Many have to face prejudice and *bullying* arising from the lack of information of the people they live with on a daily basis. In addition to affecting nutritionally, there are also the psychological effects resulting from it and which are also equally devastating. Problems such as anxiety, difficulties in social contexts, continuous clinical symptoms, and also changes in body composition are reported. "In fact, one study revealed that social phobia, as measured by the Liebowitz Social Anxiety Scale, was significantly higher in individuals with CD" (Smith, 2022). It can generate double vulnerabilities or hypervulnerability (economic, social, psychological) as a result of daily experiences of exclusion and fear due to the danger that their health runs. This phobia occurs due to food insecurity because they do not know if good practices for handling and controlling ingredients and inputs have been carried out. It can be: from attending a classroom space, in which there was gluten, or going to the playground and cafeteria, participating in events, parties, or outings, or some other place where there is food, it already causes fear of possible problems with your health. Promoting welcoming and inclusion is much more than beautiful words, it involves monitoring, control and purposeful actions and the understanding of vulnerabilities.

For Mainaier (2023), the non-conformity of menus to serve students with NAE ranges from the unavailability of food to the lack of execution of meals. Through the FNDE's Accountability Management System (SiGPC), it is possible to know that in 2021, 69% of the Executing Entities stated that they identified students with NAEs, but not all of them served with different menus. What is surprising is that even when students are identified, they continue to be unattended. What is still surprising is that 31% of the Executing Entities, that is, about 1600 municipalities, do not identify any student with NAEs, since we know that epidemiologically it makes no sense at all. This also suggests an insufficiency in public policy, in its execution and monitoring.

There are two major blocks for training for the inclusion of NAEs: first, understanding the physiological and metabolic characteristics of students and the conditions for producing a safe environment; secondly, dialogue with the institutional conditions to guarantee access and permanence, purchases, bidding, calls for special foods, request for equipment and utensils, information in the system, monitoring and control.

From this perspective, there is a perception that although training is carried out for cooks, one of the great difficulties encountered is the high turnover of outsourced employees that

impairs the technical training of professionals, hindering the process of continuous permanent training. It also makes it difficult for the kitchen/school environment to be integrated so that it obtains a good performance in the preparation of food. In addition, the possibility of a bond between the cook and the students is reduced, through an affective relationship and respect for special food needs.

Another limiting factor to full attendance is the precariousness in the infrastructure of educational establishments. The lack of specific space in the kitchens, which is sufficient and safe for handling food, and the lack of investment in the adequacy of the facilities that, in addition to affecting the safety of food production, can compromise the health of students. Still in relation to structure, utensils and equipment can be mentioned. In Marechal, there is a specific bidding for the acquisition of kitchen items, but as already explained, there is a lack of understanding of the managers regarding the need to request the responsible sector and that this failure can generate losses for the student. It is perceived that this difficulty with risk analysis and control of cross-contact and direct contact to produce food is greater in the care of allergic and celiac students. Although the number of allergic children and adolescents is small, most common sense understands the severity and speed of the reaction. Within a few hours of contact, a series of signs and symptoms become visible (Paula and Almeida, 2016).

In view of this, nutritionists and education professionals presented service options with the implementation of systems that guarantee food safety for students.

- a) Outsourcing of ready-to-eat meals with direct acquisition from a commercial establishment that strictly meets safety standards from production to distribution;
- b) Adaptation of a production site within one of the existing establishments that produces for all other locations, under a strict safety guarantee scheme in preparation, storage, transportation and distribution;
- c) Production in segregated spaces and establishing a safe production routine with locations in each school identified with the presence of students in special feeding,
- d) Production of a single menu for all students without the allergenic ingredient, reducing the risks of direct and cross-environmental contact, the impacts of special hygiene costs on equipment and surfaces and stimulating socialization.

It is important to understand that by following option c, of production in segregated spaces and establishing a safe production routine with locations in each school that has students with NAE, there are some difficulties to be overcome. The first would be the routine of cleaning and sanitizing surfaces, utensils and spaces to deglutenize and eliminate protein residues. It is known in the case of production for celiacs, how wheat flour propagates through

the air, and wheat dust can stay in the air for up to 24 hours, the challenge is enormous because in school units: What would be the cost of hygiene? What if students have multiple allergies? Would allergenic foods such as wheat flour, milk and eggs be used, for example, and what would be the correct hygiene and good practices for the next production?

Therefore, to avoid cross-contact in production, in a shared environment you would need:

- a) a place to store isolated and isolated special foods, or allergenic foods in relation to others,
- b) proper cleaning of surfaces before starting production, starting with the production of the special menu,
- c) acquiring exclusive utensils such as baking sheets, pans, molds, grills, griddles, and equipment such as blenders, ovens and capped boxes.
- d) training in good care practices so that the food handler does not become an instrument of contamination,
- e) exclusive PPE for the handler, who must wear, among other things, an exclusive apron.
- f) specific sanitizing utensils.
- g) care with the cafeteria and the serving equipment, avoiding accidents and inhibiting the exchange of food.
- h) in which cases the system can be hybrid, with production being done in another location, but stored ready at the school and heated.

The vast majority of family members and the school community do not have this information clarified and do not seek to know if in the school where their child studies there are other students with these needs and if they are being met, in addition to the fact that when the subject comes up they believe it is not of significant importance. Educational and pedagogical work is up to everyone. Thus, the promotion of events and dissemination of these guidelines is of paramount importance so that there is a greater dissemination of knowledge of these NAE and how to act so that the DHAA of these students is guaranteed more effectively. The CAE (School Feeding Council) has the duty to monitor and inspect compliance with the guidelines and regulations of the PNAE (Brasil, 2009). However, they end up focusing a lot on the structure of the kitchen, quality of the food provided, accountability of the municipality and leaving aside the requirement of compliance with the menu for students with NAE, which is also part of their obligations. The participation of the CAE and the requirement to guarantee the service to these students is fundamental, which has not been happening so far.

It should be noted that for the DHAA to be fully achieved in school, it needs to be demanded and for this, each government has the obligation to create and make available in an accessible way the necessary mechanisms so that individuals have the possibility to demand and claim their rights. In this sense, rights holders can contact their family or the people they live with, the School Feeding Council, the school, the Public Prosecutor's Office, the Public Defender's Office, the residents' association of their neighborhood or others who can support

them. Complaints/complaints can be submitted individually or in groups, and can be confidential, if they are not sure to file the complaint on your behalf (FIAN, 2021).

It is the duty of municipal managers to facilitate or promote conditions that allow compliance with the guidelines and regulations of the PNAE and the effective realization of the DHAA in the school. Therefore, at the local level, the holders of obligations are the secretaries of Education, school feeding coordinators, school principals, educators and local administration employees, in addition to the professionals responsible for the preparation of bids and public calls for the acquisition of food from the PNAE, cooks, nutritionists and technicians responsible for the PNAE. All of these must act supported by students or their guardians, the school community, the School Feeding Council, family farmers, non-governmental organizations and civil society organizations, as well as those in the business sector. It is understood, therefore, that it is up to the public authorities to guarantee conditions for these actors to exercise their responsibilities (FIAN, 2021).

It is unfair that the public power does not assume its responsibility. Because with the violation, the responsibility falls on the students' families, who should not have to worry about the safety and adequate care of their children in public environments of mandatory enrollment. How the menu can be made more flexible. When can this partnership exist and the child take the food? Under what circumstances and for how long? How to regulate? Is there a way to close trust agreements? Yes, after all, protection, prevention and precaution will be collective actions. This production not only involves nutritional and health care issues, but also education, inclusion and welcoming. Thus, meeting specific food needs is not a favor, nor a demonstration of kindness, but a guarantee of the right and fulfillment of the Municipality's obligation.

6 FINAL CONSIDERATIONS

To overcome this scenario, it is necessary to develop institutional strategies that sensitize and arouse the interest of health, food and education professionals and expand their technical knowledge on this topic so that they can both recognize pathologies and their manifestations and consequences, but that they can provide safe processes throughout the school feeding production chain. biotype-friendly and sustainable.

In short, to produce inclusion and overcome social barriers, it requires action on different fronts: a) institutional actions and public care policies; b) Training of education, health, assistance, food and justice professionals; c) Reception and monitoring of students with NAE and their families for monitoring; d) Dissemination and dissemination of knowledge about celiac and special dietary needs for all school components and for the general population.

Although many advances have been made, difficulties in guaranteeing the DHAA of students with specific dietary needs were evidenced by this study. It was pointed out that the supply of food free of cross-contact is the great challenge to be faced by the municipality, but that there are paths that can be followed so as not to violate this right. It was found that it is still necessary for civil society to act in the collection of these rights.

Finally, a movement to guarantee access, permanence and continuity of public policy that guarantees the care of a population so vulnerable to food, health and life as an imperative for citizenship.

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2015 CRISIS AND COLLECTIVE BARGAINING IN ARGENTINA: NEGATIVE NEGOTIATION AS A GOVERNMENT STRATEGY

CRISE DE 2015 E NEGOCIAÇÃO COLETIVA NA ARGENTINA: A NEGOCIAÇÃO NEGATIVA COMO ESTRATÉGIA DO GOVERNO

CRISIS DE 2015 Y NEGOCIACIÓN COLECTIVA EN ARGENTINA: LA NEGOCIACIÓN NEGATIVA COMO ESTRATEGIA DEL GOBIERNO



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ABSTRACT

This study analyzes the impacts of the 2015 economic crisis in Argentina on collective bargaining, with an emphasis on the strategy of "negative collective bargaining," defined as the deliberate limitation of wage demands and the capacity for union pressure due to restrictive macroeconomic targets. It hypothesizes that, in a context of high inflation and economic slowdown, the State intervened restrictively in negotiations, imposing limits on wage increases, especially in strategic sectors (Actis & Creus, 2015; Etchemendy & Collier, 2007). The research is qualitative, based on a literature review and document analysis, including classic and contemporary studies on labor relations and union data (Gramsci, 1991; Hyman, 1981; Kelly, 1998; Marticorena, 2014). The results indicate that collective bargaining was not eliminated, but reconfigured as a space for dispute, in which the government disciplined union action and controlled the dynamics of labor conflicts. Despite the restrictions, unionism maintained its leading role, especially at the grassroots level, demonstrating the persistence of collective mobilization as a mechanism of resistance.

Keywords: Collective Bargaining. Economic Crisis. Trade Unionism. Argentina. Labor Relations.

RESUMO

Este estudo analisa os impactos da crise econômica de 2015 na Argentina sobre a negociação coletiva, com ênfase na estratégia de "negociação coletiva negativa", definida como a limitação deliberada das demandas salariais e da capacidade de pressão sindical em função de metas macroeconômicas restritivas. Parte-se da hipótese de que, em um contexto de alta inflação e desaceleração econômica, o Estado interveio restritivamente nas negociações, impondo limites aos aumentos, especialmente em setores estratégicos (Actis & Creus, 2015; Etchemendy & Collier, 2007). A pesquisa é qualitativa, baseada em revisão bibliográfica e análise documental, incluindo estudos clássicos e contemporâneos sobre relações laborais e dados sindicais (Gramsci, 1991; Hyman, 1981; Kelly, 1998; Marticorena, 2014). Os resultados indicam que a negociação coletiva não foi eliminada, mas reconfigurada como espaço de disputa, no qual o governo disciplinou a ação sindical e

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controlou a dinâmica dos conflitos laborais. Apesar das restrições, o sindicalismo manteve protagonismo, especialmente nas bases, mostrando a persistência da mobilização coletiva como mecanismo de resistência.

Palavras-chave: Negociação Coletiva. Crise Econômica. Sindicalismo. Argentina. Relações de Trabalho.

RESUMEN

Este estudio analiza los impactos de la crisis económica de 2015 en Argentina sobre la negociación colectiva, con énfasis en la estrategia de "negociación colectiva negativa", definida como la limitación deliberada de las demandas salariales y la capacidad de presión sindical debido a objetivos macroeconómicos restrictivos. Se plantea la hipótesis de que, en un contexto de alta inflación y desaceleración económica, el Estado intervino de forma restrictiva en las negociaciones, imponiendo límites a los aumentos salariales, especialmente en sectores estratégicos (Actis & Creus, 2015; Etchemendy & Collier, 2007). La investigación es cualitativa, basada en una revisión de la literatura y análisis documental, incluyendo estudios clásicos y contemporáneos sobre relaciones laborales y datos sindicales (Gramsci, 1991; Hyman, 1981; Kelly, 1998; Marticorena, 2014). Los resultados indican que la negociación colectiva no fue eliminada, sino reconfigurada como un espacio de disputa, en el que el gobierno regulaba la acción sindical y controlaba la dinámica de los conflictos laborales. A pesar de las restricciones, el sindicalismo mantuvo su papel protagonista, especialmente a nivel de base, demostrando la persistencia de la movilización colectiva como mecanismo de resistencia.

Palabras clave: Negociación Colectiva. Crisis Económica. Sindicalismo. Argentina. Relaciones Laborales.

1 INTRODUCTION

Collective bargaining has consolidated itself as the main instrument for regulating labor relations in Argentina after the 2001 crisis, especially during the period of economic growth between 2003 and 2015. This period was marked by the expansion of parity negotiations, the strengthening of union coverage and the centrality of wage demands, evidencing the protagonism of organized workers and the institutionalization of labor conflict (Etchemendy & Collier, 2007; Atzeni & Ghigliani, 2013; CIFRA, 2017).

According to Vázquez y Medina (2020), the years of growth were accompanied by relatively stable GDP rates and moderate inflation levels, albeit with some fluctuations, setting the stage for the 2015 crisis.

From a theoretical point of view, the analysis of industrial relations can be enriched with critical approaches. Gramsci (1991) contributes to the understanding of the role of the State in mediating social conflicts, while Hyman (1981) emphasizes the political character of labor relations. Kelly (1998) highlights the centrality of collective mobilization in the dynamics of the conflict, and Marticorena (2014; 2015), Varela (2015) and Palomino (2008) highlight the link between trade unionism and recent economic policies in Argentina. Empirical studies also indicate the relevance of grassroots organizations and the complexity of segmented neo-corporatism in the country (Trajtemberg et al., 2012; MTESS, 2016; ODS-CTA Autónoma, 2016; Senén González et al., 2010; Womack, 2008).

From 2015 onwards, a turning point was configured, marked by the change in economic orientation and the active role of the State in redefining the limits of union action. The sustained increase in inflation, combined with the stagnation or contraction of economic activity, has put pressure on real wages and on traditional collective bargaining mechanisms. In this context, the government implemented the strategy of "negative negotiation", characterized by the deliberate limitation of wage demands and union achievements, in a context of growing macroeconomic instability (Actis & Creus, 2015; Actis, Lorenzini & Zelicovich, 2016; Adamson, 2002; Alfaro, 2015; Allami, 2012, 2013; Andritzky, 2006; Alvarez & Adelardi, 2015; Altimir & Devlin, 1992).

The objective of this study is to analyze the transformations in collective bargaining in the context of the 2015 crisis, highlighting the role of the State in containing wage demands and reconfiguring labor relations, considering the impact of economic policies, government strategies and union mobilization in a period of intense macroeconomic tension.

2 THEORETICAL FRAMEWORK

The analysis is based on critical approaches to labor relations. Antonio Gramsci (1991) contributes to the understanding of the role of the State in the mediation of social conflicts, highlighting the influence of power structures and hegemony in the regulation of labor relations. Richard Hyman (1981) emphasizes the political character of labor relations, stressing that collective bargaining and union conflicts are deeply influenced by state political decisions and strategies. In turn, John Kelly (1998) highlights the centrality of collective mobilization in the dynamics of conflict, reinforcing the idea that organized union action is fundamental for the definition of working conditions.

In the Argentine case, several studies show that collective bargaining functioned as a mechanism for institutionalizing conflict, articulating the relations between the State, unions, and capital (Marticorena, 2014, 2015; Atzeni & Ghigliani, 2013; Etchemendy & Collier, 2007; Varela, 2015). Research indicates that, even in periods of economic growth and expansion of collective bargaining, tensions persist between state interests, union action and economic demands, evidencing a segmented model of neo-corporatism, in which different sectors of the union movement have different levels of influence and negotiation capacity (Trajtemberg et al., 2012; MTESS, 2016; ODS-CTAAutónoma, 2016; Senén González et al., 2010; Womack, 2008).

This critical perspective allows us to understand collective bargaining not only as a technical instrument of wage adjustment, but as a space of political and social dispute, in which government strategies, workers' mobilization and articulation between different economic and institutional actors are articulated (Palomino, 2008; CIFRA, 2017; Actis & Creus, 2015; Actis, Lorenzini & Zelicovich, 2016).

3 CONTEXT OF COLLECTIVE BARGAINING IN ARGENTINA (2003–2015)

Between 2003 and 2015, collective bargaining in Argentina went through a period of significant expansion, characterized by four central dimensions: the reactivation of parity negotiations, the expansion of union coverage, the centrality of wage demands, and the institutionalization of labor conflict. For example, during this period, strategic sectors such as metallurgical, chemical and transport resumed periodic wage negotiations, while unions such as the Asociación de Trabajadores del Estado (ATE) and the Unión de Personal Civil de la Nación (UPCN) were able to expand their base of representation, ensuring greater coverage in public and state bodies (Etchemendy & Collier, 2007; Atzeni & Ghigliani, 2013).

This period highlights the articulation between economic growth and the strengthening of labor institutions. Between 2003 and 2007, the country presented GDP growth rates of more

than 8% per year, accompanied by expansion of formal employment and relative stability of real wages, creating a favorable scenario for collective bargaining (CIFRA, 2017). The centrality of wage demands was manifested in sectoral agreements that included not only wage increases, but also productivity bonuses and improvements in working conditions in industries such as steel and petrochemicals, demonstrating the relevance of negotiations as a mechanism for economic redistribution (Trajtemberg et al., 2012; Senén González et al., 2010).

The protagonism of organized workers reflected a segmented model of neo-corporatism, in which different sectors of the union movement had different levels of influence and negotiation capacity. Unions with a greater historical presence and structured organization, such as the CGT (Confederación General del Trabajo), were able to push for consistent increases and for the incorporation of wage indexation clauses, while more peripheral sectors faced limitations in representation and impact on agreements (Womack, 2008).

Previous studies also highlight that collective bargaining functioned as a mechanism for institutionalizing conflict, articulating the relations between the State, unions and capital. For example, agreements in the public sector often resulted from direct mediation by state agencies, while in private industry negotiations were mediated by business chambers and union federations, demonstrating the complexity of the interaction between actors and the regulatory role of the state (Marticorena, 2014, 2015; Varela, 2015; Palomino, 2008).

In short, the period between 2003 and 2015 not only expanded the scope of collective bargaining, but also consolidated it as a central space for dispute and social articulation, reflecting both the relative strength of unions and the capacity of the State to structure labor conflict within institutionalized parameters.

4 THE 2015 CRISIS AND NEGATIVE NEGOTIATION

From 2015 onwards, with the change in the government's economic orientation, there was a significant reconfiguration of labor relations in Argentina. This period was marked by the implementation of the so-called "negative negotiation", characterized by explicit strategies of wage restraint and union discipline. Among its main manifestations are:

- The imposition of strict limits on wage increases, often below real inflation, as occurred in strategic sectors of industry and public transport;
- The direct intervention of the State in negotiations, mediating agreements between unions and employers, often conditioning the approval of collective agreements to the containment of wage expenditures;

- the promotion of wage agreements that did not fully compensate for the loss of purchasing power, reflecting a deliberate policy of containing labor costs;
- The weakening of the capacity for union pressure, through regulations, restrictions on mobilization and limitation of the participation of the rank and file in sectoral negotiations (Actis & Creus, 2015; Actis, Lorenzini & Zelicovich, 2016; Adamson, 2002; Alfaro, 2015; Allami, 2012, 2013; Andritzky, 2006; Alvarez & Adelardi, 2015; Altimir & Devlin, 1992).

In this context, the State assumed a disciplinary role, prioritizing macroeconomic stability over the recomposition of workers' wages, reflecting a logic in which collective agreements ceased to be instruments of redistribution and began to operate as mechanisms to contain union demands.

Sectors such as transportation, energy, and public administration recorded negotiations in which average increases did not exceed 10% per year, despite inflation rates above 20%, evidencing the mismatch between wage growth and real inflation. In addition, the government used measures such as the imposition of wage caps and mandatory conflict mediation to limit strikes and pressure for more significant increases, demonstrating the strategic use of collective bargaining as an instrument of economic policy (Actis & Creus, 2015; Marticorena, 2014; Varela, 2015).

"Negative bargaining" transformed the dynamics of labor relations, shifting the balance between workers, unions, and the State, and signaling that, in contexts of macroeconomic instability and containment policies, collective bargaining functioned more as an instrument of regulation and discipline than as a mechanism for expanding rights.

5 IMPACTS ON UNIONISM

The implementation of the "negative negotiation" strategy has had significant effects on Argentine trade unionism. Among the main impacts are the reduction in the bargaining power of unions, especially in strategic sectors such as transport, energy and public administration, where the historical unions have had their ability to impose substantial wage increases limited by the government and the employers' chambers. In addition, there was an increase in labor conflict, with episodes of partial strikes, protests, and grassroots mobilizations that sought to compensate for the restriction of formal increases (Etchemendy & Collier, 2007; MTESS, 2016).

In some sectors, such as health and education, the weakening of the central union leaderships led to a greater role of the rank-and-file, which began to press directly for wage increases and better working conditions, even in fragmented and localized contexts. This dynamic contributed to the fragmentation of the trade union movement, evidenced by the

multiplication of smaller unions and internal dissidence within historical confederations (Atzeni & Ghigliani, 2013; ODS-CTA Autónoma, 2016; Varela, 2015).

Despite these restrictions, collective bargaining remained a central space for dispute, albeit under more limited conditions. Even in a context of economic restraint, unions continued to play a relevant political and social role, acting as mediators between workers, the State and capital, and as channels of demands that influenced government decisions and sectoral public policies (Etchemendy & Collier, 2007; Atzeni & Ghigliani, 2013; MTESS, 2016; ODS-CTA Autónoma, 2016; Varela, 2015).

6 METHODOLOGY

This study adopts a qualitative approach, centered on the critical analysis of collective bargaining in Argentina, focusing on the transformations that occurred during the period from 2003 to 2015 and on the reconfiguration of labor relations from 2015 onwards, marked by the implementation of the "negative negotiation" strategy.

The research is mainly based on literature review and documentary analysis. Classical and contemporary academic studies on labor relations were used (Gramsci, 1991; Hyman, 1981; Kelly, 1998; Marticorena, 2014, 2015), as well as institutional reports, official data on collective bargaining, wage statistics and publications by trade union organizations (CIFRA, 2017; MTESS, 2016; ODS-CTA Autónoma, 2016). The analysis also included case studies on strategic sectors of the Argentine economy, allowing the identification of patterns, strategies and effects of state and union action.

The methodological approach prioritizes the dialogue between theory and empiricity, articulating concepts of segmented neo-corporatism, union mobilization, and state intervention, in order to understand both the formal mechanisms of collective bargaining and the underlying dynamics of social and political conflict. The analysis sought to identify recurrent elements that evidence the institutionalization of the conflict, the centrality of wage demands and the relationship between macroeconomic stability and the negotiation capacity of unions.

The research also adopts a historical-comparative character, contextualizing the expansion of collective bargaining between 2003 and 2015, the impact of the 2015 crisis and the state response in the form of "negative bargaining". This approach allows us to understand the evolution of the labor relations system, highlighting concrete examples of wage policies, sectoral agreements and union strategies.

Finally, the methodology applied guarantees a critical and detailed analysis of the theme, articulating multiple sources of information and allowing the evaluation of the interactions

between the State, unions and capital, as well as the effects of economic policies on collective bargaining and Argentine unionism.

7 RESULT AND DISCUSSION

The results indicate that, between 2003 and 2015, collective bargaining in Argentina was consolidated as the main mechanism for regulating labor relations, promoting the institutionalization of conflict and strengthening the role of organized unions. The analysis of historical data and case studies reveals that the reactivation of parity negotiations, the expansion of union coverage, and the centrality of wage demands allowed strategic sectors, such as metallurgy, transportation, and public services, to negotiate consistent wage increases, bonuses, and improvements in working conditions, strengthening the pressure capacity of the union rank and file (Etchemendy & Collier, 2007; Atzeni & Ghigliani, 2013; CIFRA, 2017; Trajtemberg et al., 2012; Senén González et al., 2010; Womack, 2008).

From 2015 onwards, there was a reconfiguration of the labor scenario, marked by the adoption of the "negative negotiation" strategy. The results indicate that this policy reduced the bargaining power of unions, promoted wage agreements below inflation and weakened the capacity for union pressure. In sectors such as public transport and public administration, average wage increases did not exceed 10% per year, while inflation exceeded 20%, evidencing the discrepancy between wage gains and cost of living (Actis & Creus, 2015; Actis, Lorenzini & Zelicovich, 2016; Adamson, 2002; Alfaro, 2015).

The analysis also reveals that, even under restrictive conditions, unionism has not been eliminated. On the contrary, in some sectors there was a greater role of the rank-and-file, which assumed an active role in negotiation and mobilization, resulting in the fragmentation of the trade union movement and an increase in labor conflict (Etchemendy & Collier, 2007; Atzeni & Ghigliani, 2013; MTESS, 2016; ODS-CTA Autónoma, 2016; Varela, 2015). These results indicate that collective bargaining continued to be a space for political and social dispute, although under a regime of wage restraint and economic discipline promoted by the State.

The discussion of the results suggests that the 2015 crisis not only changed the dynamics of wage negotiations, but also highlighted the State's capacity to redefine the limits of union action. While in previous years unions were able to expand coverage and consolidate wage gains in strategic sectors, "negative negotiation" restricted these achievements and imposed clear limits on union action.

However, the persistence of grassroots mobilizations and the negotiation of sectoral agreements demonstrate that the collective strength of workers still functioned as a mechanism

of resistance and regulation of labor relations (Marticorena, 2014, 2015; Palomino, 2008; Varela, 2015).

In summary, the results indicate that collective bargaining in Argentina is simultaneously an instrument of institutionalization of conflict and an arena of political dispute. The economic crisis of 2015 and wage containment policies reinforce the idea that the effectiveness of collective bargaining depends on the capacity of the State, the union organization and the macroeconomic context, configuring a complex balance between economic stability and labor rights.

8 CONCLUSION

The present study demonstrated that collective bargaining in Argentina, far from being a static or merely formal practice, has functioned as a central space of political and social dispute over the last decades. Between 2003 and 2015, it was consolidated as an instrument capable of articulating the interests of workers, unions and the State, in a context of economic expansion and strengthening of labor institutions. From 2015 onwards, however, this balance was profoundly altered by the emergence of a new pattern of state intervention in labor relations that this author proposes to conceptualize as "negative collective bargaining" a process in which the State not only moderates wage demands, but systematically conditions, limits and redirects collective bargaining according to restrictive macroeconomic goals, reducing the capacity for union pressure and converting the negotiation space into an instrument of labor discipline.

This concept of negative collective bargaining does not simply describe a temporary containment of wage increases, but a reconfiguration of labor relations in which the institutional mechanisms of mediation cease to be arenas of effective dispute for social advances to become tools for containing demands, inserting collective bargaining in a logic of structural limitations imposed by the State.

The importance of this text as an object of study in graduate programs lies in its ability to unite historical, critical, and empirical analysis of labor relations with a crucial contemporary debate on the role of the State, trade unionism, and economic policies in crisis contexts. Additionally, due to the growing interdependence of economies and the circulation of neoliberal policies on a global scale, this work can enrich international exchange programs by offering students and researchers an in-depth understanding of the challenges faced by collective bargaining regimes, allowing comparisons with experiences from other countries, and encouraging theoretical dialogues on labor relations models in booming and crisis cycles.

Reflecting on the current Argentine political and social moment, the recent labor reform promoted by the government of *Javier Milei* represents a significant social setback in the field of labor rights. The reform, which extended the working day, made contracts more flexible, changed the calculation of compensation and imposed restrictions on the right to strike, symbolizes a decisive turn towards the deregulation and precariousness of working conditions, a transformation that many analysts, unions and social movements qualify as an attempt to weaken the historical achievements of the Argentine labor movement and to subordinate labor relations to the demands of capital and the markets.

This set of changes, instead of offering an equitable "modernization", tends to widen power asymmetries, reduce basic protections for workers, and deepen social vulnerability, characteristics that, in the author's assessment, represent a significant setback in the framework of labor rights built over years of collective struggles and negotiations.

Finally, this research reaffirms that collective bargaining is not a mere technical artifact, but a field of struggle, deeply conditioned by economic and political transformations. Understanding its multiple configurations, including negative forms of negotiation, is essential not only to decipher Argentina's recent past, but also to anticipate and critically respond to contemporary challenges of labor relations in contexts of crisis and global reorganization.

9 INSTITUTIONAL NOTE

The present study was delivered to the Graduate Office of the Universidad Nacional de Córdoba as a mandatory requirement for the qualification of the Graduate Program in Law and Social Sciences, at the third face-to-face meeting held in Córdoba, Argentina, in July 2015, under the title: Thesis Project. Its development was interrupted in July 2017, under the agreement with ISPED.

Although the study was originally developed in the context of 2015, its analysis in this research has been revised and updated, remaining relevant to understanding the current challenges of labor relations in Argentina. In our assessment, the reform of the Milei government, known as part of the package of economic deregulation measures often associated with the Basic Law (or "Bus Law") and the Decree of Necessity and Urgency (DNU) No. 70/2023 may compromise social and redistributive advances. Such a scenario reinforces the importance of studies like this one to monitor, analyze and critically debate the transformations in labor relations in the country.

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DIFFERENTIAL RESPONSE OF TROPICAL, TEMPERATE, AND TEMPERATE × TROPICAL MAIZE HYBRIDS IN YIELD AND STARCH CONTENT TO ENVIRONMENTAL VARIABILITY IN CHACO PROVINCE

RESPOSTA DIFERENCIAL DE HÍBRIDOS DE MILHO TROPICAIS, TEMPERADOS E TEMPERADOS × TROPICAIS NO RENDIMENTO E TEOR DE AMIDO À VARIABILIDADE AMBIENTAL NA PROVÍNCIA DO CHACO

RESPUESTA DIFERENCIAL EN RENDIMIENTO Y CONTENIDO DE ALMIDÓN DE HÍBRIDOS DE MAÍZ TROPICALES, TEMPLADOS Y TEMPLADO × TROPICAL FRENTE A VARIACIONES AMBIENTALES EN LA PROVINCIA DEL CHACO



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ABSTRACT

Chaco Province (Argentina) is characterized by extensive arable land and marked environmental heterogeneity, which directly impact productive development and enable high maize production levels. Although previous studies have compared average yields among hybrids, understanding the response of different genetic groups to environmental variability remains essential. This study analyzed the differential response in grain yield and starch content of tropical, temperate × tropical, and temperate maize hybrids grown across different locations in the province, considering edaphic and climatic conditions based on previously published data. Results indicated that the temperate group achieved the highest average grain yield (82.20 qq/ha) and a high starch content (73.48%), although its performance varied depending on environmental conditions. The tropical group showed a lower average grain yield (70.71 qq/ha) but exhibited differential responses, particularly in environments with

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variations in precipitation and soil type. Overall, the results suggest that hybrid selection should not rely solely on average yield but also on adaptation to specific environmental conditions. Environmental factors such as precipitation (308–820 mm) and soil characteristics (organic matter: 0.40–1.50%) influenced the expression of the genetic potential of each group. It is concluded that a significant interaction exists between genetic group and environment, which is critical for the recommendation of hybrid materials across the different productive subregions of Chaco.

Keywords: Maize (*Zea mays* L.). Hybrids. Grain. Yield. Starch Content. Genotype × Environment Interaction.

RESUMO

A Província do Chaco (Argentina) caracteriza-se por extensas áreas agricultáveis e marcada heterogeneidade ambiental, fatores que impactam diretamente o desenvolvimento produtivo e possibilitam elevados níveis de produção de milho. Embora estudos anteriores tenham comparado os rendimentos médios entre híbridos, compreender a resposta de diferentes grupos genéticos à variabilidade ambiental continua sendo essencial. Este estudo analisou a resposta diferencial no rendimento de grãos e no teor de amido de híbridos de milho tropicais, temperados × tropicais e temperados cultivados em diferentes localidades da província, considerando as condições edáficas e climáticas com base em dados previamente publicados. Os resultados indicaram que o grupo temperado apresentou o maior rendimento médio de grãos (82,20 qq/ha) e elevado teor de amido (73,48%), embora seu desempenho tenha variado de acordo com as condições ambientais. O grupo tropical apresentou menor rendimento médio de grãos (70,71 qq/ha), mas demonstrou respostas diferenciais, especialmente em ambientes com variações de precipitação e tipo de solo. De modo geral, os resultados sugerem que a seleção de híbridos não deve se basear apenas no rendimento médio, mas também na adaptação às condições ambientais específicas. Fatores ambientais, como precipitação (308–820 mm) e características do solo (matéria orgânica: 0,40–1,50%), influenciaram a expressão do potencial genético de cada grupo. Conclui-se que existe interação significativa entre grupo genético e ambiente, fator essencial para a recomendação de materiais híbridos nas diferentes sub-regiões produtivas do Chaco.

Palavras-chave: Milho (*Zea mays* L.). Híbridos. Grãos. Rendimento. Teor de Amido. Interação Genótipo × Ambiente.

RESUMEN

La provincia del Chaco (Argentina) presenta amplias superficies cultivables y una marcada heterogeneidad ambiental, que generan un impacto directo en el desarrollo productivo y permiten alcanzar altos volúmenes de producción de maíz. Si bien estudios previos han comparado rendimientos promedio entre híbridos, resulta fundamental comprender la respuesta de los distintos grupos genéticos frente a la variabilidad ambiental. En este trabajo se analizó la respuesta diferencial en rendimiento en grano y contenido de almidón de híbridos de maíz tropicales, templado × tropical y templados, cultivados en distintas localidades de la provincia, considerando condiciones edáficas y climáticas a partir de datos previamente publicados. Los resultados indicaron que el grupo templado presentó el mayor rendimiento promedio en grano (82,20 qq/ha) y un alto contenido de almidón (73,48 %), aunque con variaciones en su desempeño según el ambiente. El grupo tropical mostró un menor rendimiento promedio (70,71 qq/ha), pero evidenció respuestas diferenciales, particularmente en ambientes con variaciones en la precipitación y el tipo de suelo. En conjunto, los resultados sugieren que la elección del híbrido no debe basarse únicamente en el rendimiento promedio, sino también en su adaptación a condiciones específicas. Factores

ambientales como la precipitación (308–820 mm) y las características edáficas (materia orgánica: 0,40–1,50 %) influyeron en la expresión del potencial genético. Se concluye que existe una interacción significativa entre el grupo genético y el ambiente, lo cual resulta clave para la recomendación de materiales híbridos en las distintas subregiones productivas del Chaco.

Palabras clave: Maíz (*Zea mays* L.). Híbridos. Rendimiento de Grano. Contenido de Almidón. Interacción Genotipo × Ambiente.

1 INTRODUCTION

The challenge for agricultural production in Argentina lies in seizing the opportunity to supply the growing global demand for food and renewable energy [1]. In this context, corn occupies a strategic role, both in crop rotation and as a source of raw material for various production chains [1].

The province of Chaco is an extra-Pampas region relevant in corn production [2], although its planted area and production levels are strongly conditioned by climatic factors [3]. In this framework, the development of hybrids has made it possible to improve genetic characteristics associated with yield and tolerance to adverse conditions [4, 5], including biotic [6] and abiotic factors such as water availability [7] and herbicide tolerance [8].

Grain yield and quality are determined by genotype, environment, and their interaction ($G \times E$) [9, 10]. Environmental factors such as temperature [11, 13, 15] and solar radiation [12] influence crop growth and grain composition, particularly characteristics such as starch content and structure [14]. The quality of the grain, including components such as starch, protein and oil, is key to its industrial use [16, 17].

In this sense, sustainable regional development [19] promotes the addition of value to primary production. The use of corn for bioenergy generation in northern Argentina represents an alternative to strengthen the value chain, contribute to sustainability, and generate employment [19], although its implementation depends on appropriate policy frameworks [20].

Previous studies carried out in the province of Chaco have compared the average yield and starch content of different hybrids. However, the marked environmental variability within the province [Tables 2 and 3] makes it necessary to advance in the analysis of the differential response of genetic materials, beyond the average values. In particular, it is relevant to understand how different groups of hybrids (tropical, temperate $\times$ tropical and temperate) respond to this environmental heterogeneity.

The objective of this study was to analyze the differential response in grain yield and starch content of groups of maize hybrids (tropical, temperate $\times$ tropical and temperate) to environmental variations in different localities of the province of Chaco, using previously reported group average data.

2 DEVELOPMENT AND METHODOLOGY

This analysis was based on data collected from a previous comparative study conducted in Chaco Province, Argentina. In this study, planting blocks with maize genetic materials classified into three groups were evaluated: tropical, temperate $\times$ tropical and temperate (Table

1), implanted in various agricultural farms located between Latitude 26° 00' 46.4" and 27° 57' 45.72" S, and Longitude 60° 08' 36.76" and 61° 41' 19.28" W (Figure 1).

Figure 1

Georeferencing

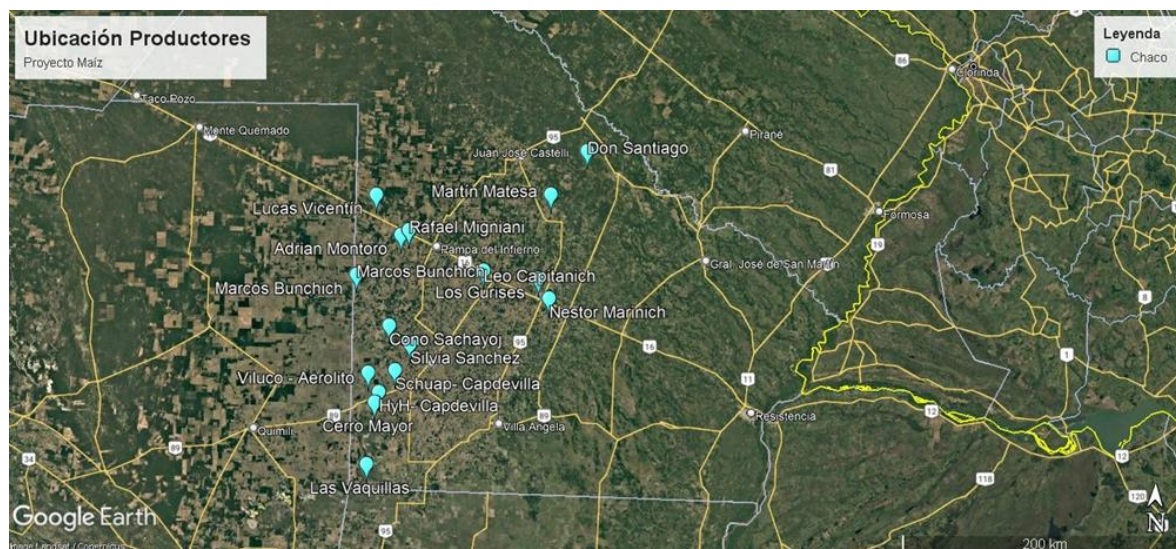


Table 1

Types of Materials Used

Tropical	Temperate x Tropical	Temperate
DK390VT3P	DK7910VT3P	DK7210VT3P
NK139VIP3	LT795VT3P	DK7310VT3P
P30F53HXRR2	2A120PW	2M510PW

Source: Authors.

The environmental conditions of the experimental sites were characterized by meteorological variables, including mean temperature, precipitation and effective heliophany (Table 2), and edaphic variables, such as organic matter content, nitrogen, phosphorus and soil pH (Table 3).

Table 2

Meteorological Data of Localities of the Province of Chaco

Locations	Average Temperature (°C)	Rainfall (mm)	Effective Heliophany (hs)
Los Frentones (AM)	22,64	308	7,367

Long Camp (LC)	24,40	353	7,367
Dead River (LV)	22,64	707	7,367
Pampa del Infierno (MG)	23,48	360	6,873
Pampa del Infierno (LG)	23,48	360	6,873
Las Breñas (MB)	24,4	413	7,367
Tres Isletas (Ma)	24,02	642	6,873
Tres Isletas (DS)	24,02	820	6,873
P. R. Sáenz Peña (NM)	24,03	433	6,873
Beautiful Field (CM)	23,67	441	7,367
Charata (SS)	24,4	336	7,367
Gen. Capdevila (Sch)	24,35	384	7,367
General Capdevila (HyH)	24,35	447	7,367
General Capdevila (VL)	24,35	420	7,367

Source: Authors.

Table 3

Soil Data

Location	Producer	Soil Factors			
		Matt. Organic [%]	Nitrogen [ppm]	Phosphorus [ppm]	pH
The Frentones	AM	0,40	0,07	77,00	7,30
Long Camp	LC	0,42	0,07	13,10	7,00
Dead River	LV	0,56	0,08	63,50	6,70
Pampa del Infierno	LG	1,27	0,15	67,10	7,50
Pampa del Infierno	MG	0,40	0,07	77,00	7,30
Las Breñas	MB	1,00	0,12	58,55	6,45
Three Islets	Ma	0,56	0,08	63,50	6,70
Three Islets	DS	0,58	0,09	65,50	6,70
P. R. Sáenz Peña	NM	1,50	0,12	55,80	7,60
Beautiful Countryside	C M	0,83	0,08	49,00	7,30
Charata	Sa	0,77	0,10	74,20	6,50
General Capdevila	Sch	1,07	0,09	64,34	7,04
General Capdevila	HyH	1,29	0,13	59,90	7,60
General Capdevila	VL	1,12	0,13	46,40	6,90

Source: Authors.

For the present study, we used only average data by group of hybrids and locality, corresponding to: (I) grain yield (qq/ha) (Table 4), and (II) starch content (%) (Table 5).

Table 4

Average Yield in qq/ha by Localities

Locations	Average Yield (qq/ha)			Average
	Tropical	Temperate x Tropical	Temperate	
Los Frentones (AM)	73,07	72,51	75,76	73,78
Long Camp (LC)	60,44	57,43	68,16	62,01
Dead River (LV)	81,23	84,76	91,28	85,76
Pampa del Infierno (LG)	72,23	86,99	94,35	84,52
Pampa del Infierno (MG)	66,17	61,73	75,03	67,64
Las Breñas (MB)	68,78	75,55	85,3	76,54
Tres Isletas (Ma)	36,81	56,37	46,84	46,67
Tres Isletas (DS)	68,50	62,72	61,92	64,38
P. R. Sáenz Peña	50,49	50,10	57,73	52,77
Beautiful Field (C M)	69,5	76,17	98,94	81,54
Charata (SS)	84,69	89,42	84,85	86,32
Gen. Capdevila (Sch)	90,09	87,78	107,05	94,97
General Capdevila (HyH)	86,37	94,77	103,64	94,93
General Capdevila (VL)	81,51	85,01	100,00	88,84
Average	70,71	74,38	82,20	75,76

Source: Authors.

Table 5

Average Starch Content of the Hybrids Tested

Locations	Tropical	Temperate x Tropical	Temperate	Average
The Frentones	74,28	73,27	74,32	73,96
Long Camp	75,48	74,53	73,44	74,48
Dead River	69,57	70,57	73,10	71,08
Pampa del Infierno	71,22	73,05	73,65	72,64
Las Breñas	73,53	73,69	73,18	73,47
Three Islets	75,21	74,43	73,75	74,46

Sáenz Peña	74,56	73,75	73,22	73,84
Beautiful Countryside	72,39	72,32	74,66	73,12
Charata	69,99	71,05	72,52	71,19
General Capdevila	71,84	70,73	72,95	71,84
Average	72,81	72,74	73,48	73,01

Source: Authors.

The differential response of the hybrid groups to environmental variability was evaluated by:

- Visual analysis, examining patterns of yield and starch content between localities, with emphasis on changes in the relative ranking of groups.
- Quantification of variability, by calculating the standard deviation (SD) and the coefficient of variation (CV) for each genetic group, as indicators of response stability.
- Qualitative correlation analysis, relating the relative performance of the groups with the environmental characteristics of each locality, in order to identify factors potentially associated with the observed variation.

It should be noted that the analysis was carried out at the level of groups of hybrids, using average values. Consequently, inferences about stability and differential response correspond to the mean behavior of each group and not to individual hybrids.

3 RESULTS AND DISCUSSION

The data on grain yield (Table 4) and starch content (Table 5) constitute the basis for the analysis of the differential response of the groups of hybrids to environmental variability.

In terms of yield, the temperate group presented the highest general average (82.20 qq/ha), surpassing the temperate × tropical group (74.38 qq/ha) and the tropical group (70.71 qq/ha). However, the magnitude of this superiority varied between localities, evidencing a marked genotype × environment (G×E) interaction. In high-potential environments, such as Río Muerto, Pampa del Infierno (LG) and localities of General Capdevila, the temperate group reached the highest yield values. In contrast, in more restrictive environments, such as Tres Isletas (Ma) and Campo Largo, yields were lower and differences between groups were reduced, with changes in the relative ranking being observed.

The variability of yield between environments, estimated by standard deviation, was greater in the temperate group (≈17.8 qq/ha), compared to the temperate × tropical (≈12.6

qq/ha) and the tropical (≈ 14.6 qq/ha) groups. This result suggests that, although the temperate group has greater productive potential, it also exhibits greater sensitivity to environmental conditions, which reinforces the existence of a significant G×E interaction.

In relation to starch content, the differences between groups were less marked. The average values were similar between temperate (73.48%), tropical (72.81%) and temperate × tropical (72.74%), with no evidence of a consistently higher group in all localities. However, occasional variations were observed, such as in Campo Largo, where the tropical group reached the highest starch content, and in Hermoso Campo, where the temperate group presented the highest values.

The variability of starch content was considerably lower than that of yield, especially in the temperate group ($SD \approx 0.8\%$), indicating greater stability of this quality variable in the face of environmental changes. In this sense, the relationship between yield and starch content was not direct, since high-performance environments were not necessarily associated with higher starch contents.

The joint analysis with the environmental variables (Tables 2 and 3) did not show simple associations between a single factor (such as precipitation or organic matter content) and the performance of the groups. For example, localities with high rainfall, such as Tres Isletas (DS), did not systematically present the highest yields, while environments with low levels of organic matter showed variable responses. Likewise, in General Capdevila, the high yields observed in all groups, despite edaphic variations, suggest the influence of other local or management factors not considered.

Taken together, these results confirm that the response of hybrid groups is determined by a complex interaction between climatic, edaphic, and management factors, in accordance with what has been reported in the literature [9, 10, 15]. The temperate group tends to maximize its potential in favorable environments, while the tropical and temperate × tropical groups present more variable responses, which could be associated with differences in adaptation and phenotypic plasticity.

It should be noted that the use of group averages constitutes a limitation for interpretation at the level of individual hybrids. However, the results obtained are relevant from the agronomic point of view, since they indicate that the classification by genetic origin (tropical vs. temperate) has implications in the adaptation to the environmental heterogeneity of the province of Chaco.

4 CONCLUSIONS

The analysis of the response of groups of maize hybrids in different localities of the province of Chaco showed a significant interaction between the genetic group and the environment ($G \times E$).

The temperate group presented the highest average yield, although it also showed the greatest variability between environments, indicating a greater sensitivity to environmental conditions. In contrast, the starch content was relatively similar between groups, with the temperate group standing out for its greater stability in this variable.

No simple relationships were identified between isolated environmental factors and the differential response of the groups, suggesting a complex interaction of multiple variables that modulate the expression of genetic potential.

From a productive perspective, the selection of hybrids in the province of Chaco must consider not only the average yield, but also the specific adaptation to the environmental conditions of each locality.

Finally, while this study provides evidence at the group level, scaled analyses of individual hybrids are required to deepen the assessment of stability and specific adaptation.

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THE USE OF ICTS IN ADAPTING ACTIVITIES FOR TEACHING MATHEMATICS IN ADULT EDUCATION (HIGH SCHOOL LEVEL)

A UTILIZAÇÃO DAS TDICs NA ADAPTAÇÃO DE ATIVIDADES PARA O ENSINO DA MATEMÁTICA NA EJA MÉDIO

EL USO DE LAS TIC EN LA ADAPTACIÓN DE ACTIVIDADES PARA LA ENSEÑANZA DE LAS MATEMÁTICAS EN LA EDUCACIÓN DE ADULTOS (SECUNDARIA)



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ABSTRACT

This study addresses the use of Digital Information and Communication Technologies (DICTs) in mathematics education within Youth and Adult Education (YAE), a modality characterized by interrupted school trajectories, sociocultural diversity, and historical learning challenges. The objective was to investigate how DICTs have been used to adapt mathematical activities for YAE high school students, analyzing theoretical productions, teaching materials, and educational documents. Methodologically, it is a bibliographic and documentary research, with a qualitative approach and a pedagogical-propositional character, organized through analytical categories that enabled a critical interpretation of the findings. Results indicate that DICTs, when integrated into pedagogical proposals planned and critically mediated by teachers, can enhance the visualization of mathematical concepts (C1), increase student engagement through gamification (C2), and promote more meaningful and contextualized learning experiences (C3). The analysis also highlights limitations related to precarious technological infrastructure, digital access inequalities, and gaps in teacher training (C4). It is concluded that the integration of DICTs into mathematics teaching in YAE represents a promising path for building more inclusive and contextualized pedagogical practices, provided it is articulated with teacher training policies and digital inclusion initiatives. The main contribution of this research lies in the articulation between theoretical analysis and pedagogical proposition, by presenting a set of didactic activities adapted with DICTs, offering concrete support for teachers and researchers interested in more critical, inclusive, and transformative practices in mathematics education within YAE.

Keywords: Youth and Adult Education. Mathematics Teaching. Digital Inclusion. Pedagogical Practices. Digital Technologies.

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RESUMO

Este trabalho insere-se no debate sobre o uso das Tecnologias Digitais da Informação e Comunicação (TDICs) no ensino da matemática na Educação de Jovens e Adultos (EJA), modalidade marcada por trajetórias escolares interrompidas, diversidade sociocultural e desafios históricos de aprendizagem. O objetivo foi investigar como as TDICs vêm sendo utilizadas na adaptação de atividades matemáticas para estudantes da EJA no Ensino Médio, analisando produções teóricas, materiais didáticos e documentos educacionais. Metodologicamente, trata-se de uma pesquisa bibliográfica e documental, de abordagem qualitativa e caráter propositivo-pedagógico, organizada a partir de categorias analíticas que possibilitaram interpretação crítica dos achados. Os resultados indicam que as TDICs, quando integradas a propostas pedagógicas planejadas e mediadas criticamente pelo professor, favorecem a visualização de conceitos matemáticos (C1), ampliam o engajamento discente por meio da gamificação (C2) e promovem aprendizagens significativas e contextualizadas às vivências dos estudantes (C3). A análise também evidencia limites associados à infraestrutura tecnológica precária, às desigualdades de acesso digital e às lacunas na formação docente (C4). Conclui-se que a integração das TDICs ao ensino da matemática na EJA constitui um caminho promissor para práticas pedagógicas mais inclusivas e contextualizadas, desde que articulada a políticas de formação docente e inclusão digital. A principal contribuição da pesquisa está na articulação entre análise teórica e proposição pedagógica, ao apresentar atividades didáticas adaptadas com TDICs, oferecendo subsídios concretos para professores e pesquisadores interessados em práticas críticas, inclusivas e transformadoras no ensino da matemática na EJA.

Palavras-chave: Educação de Jovens e Adultos. Ensino de Matemática. Inclusão Digital. Práticas Pedagógicas. Tecnologias Digitais.

RESUMEN

Este trabajo se enmarca en el debate sobre el uso de las Tecnologías de la Información y la Comunicación Digitales (TICD) en la enseñanza de las matemáticas en la Educación de Jóvenes y Adultos (EJA), una modalidad marcada por trayectorias escolares interrumpidas, diversidad sociocultural y desafíos históricos en el aprendizaje. El objetivo fue investigar cómo se han utilizado las TICD en la adaptación de actividades matemáticas para estudiantes de EJA en la escuela secundaria, analizando producciones teóricas, materiales didáticos y documentos educativos. Metodológicamente, se trata de una investigación bibliográfica y documental, con un enfoque cualitativo y un carácter proposicional-pedagógico, organizada a partir de categorías analíticas que permitieron una interpretación crítica de los hallazgos. Los resultados indican que las TICD, cuando se integran en propuestas pedagógicas planificadas y mediadas críticamente por el docente, favorecen la visualización de conceptos matemáticos (C1), aumentan la participación del alumnado mediante la gamificación (C2) y promueven un aprendizaje significativo y contextualizado relacionado con las experiencias del alumnado (C3). El análisis también pone de relieve las limitaciones asociadas a la infraestructura tecnológica precaria, las desigualdades en el acceso digital y las brechas en la formación docente (C4). El estudio concluye que la integración de las TIC en la enseñanza de las matemáticas en la educación de adultos constituye una vía prometedora para prácticas pedagógicas más inclusivas y contextualizadas, siempre que se articule con la formación docente y las políticas de inclusión digital. La principal contribución de la investigación radica en la articulación entre el análisis teórico y la propuesta pedagógica, mediante la presentación de actividades didáticas adaptadas con TIC, que ofrecen apoyo concreto a docentes e investigadores

interesados en prácticas críticas, inclusivas y transformadoras en la enseñanza de las matemáticas en la educación de adultos.

Palabras clave: Educación de Jóvenes y Adultos. Enseñanza de las Matemáticas. Inclusión Digital. Prácticas Pedagógicas. Tecnologías Digitales.

1 INTRODUCTION

Digital Information and Communication Technologies (DICTs) comprise a set of resources, tools, and digital environments that make it possible to produce, share, and transform information, promoting significant changes in social and educational practices. In the contemporary school context, the role of DICTs goes beyond the merely instrumental use of devices, involving new ways of thinking, interacting and learning, aligned with the dynamics of digital culture. As analyzed by Anjos et al. (2024), the evolution of educational technologies shows a progressive transition from analog resources to more complex and intelligent digital systems, a process marked by challenges related to teacher training, inequality of access, limited infrastructure, and the need for qualified pedagogical mediation.

In this sense, the authors highlight that DICTs expand the possibilities of communication, collaboration and creation, favoring student protagonism in more active, dynamic and contextualized learning processes. However, the pedagogical use of these technologies requires not only technical mastery, but, above all, educational intentionality and critical understanding of the cultural transformations that characterize the contemporary digital scenario, pointing to perspectives based on the personalization of learning, the integration of multiple languages, and the construction of innovative pedagogical practices (Anjos et al., 2024).

Youth and Adult Education (EJA), in turn, is configured as a teaching modality aimed at guaranteeing the right to schooling of subjects who did not complete Basic Education at the regular age, as a result of socioeconomic inequalities, early insertion in the world of work, family responsibilities, migrations and school trajectories marked by successive dropouts or failures (Almeida; Silva; Torres, 2021; Ferreira, 2024). In high school, this commitment intensifies, requiring pedagogical practices that recognize and value the life trajectories of students, especially in the teaching of mathematics, a discipline historically associated with abstraction and processes of exclusion. According to Freire (2005), the so-called "banking education" reinforces this exclusion by treating students as passive receptacles of content, in a teaching model that deposits information without dialogue or problematization. Overcoming this logic implies adopting critical and liberating pedagogical practices, capable of promoting active participation, collective construction of knowledge and appreciation of the experiences of EJA subjects.

In the context of EJA Médio, a heterogeneous public is observed, composed of young people and adults who reconcile work, family and studies, returning to school in search of professional qualification, social ascension or personal fulfillment. These students have diverse

life experiences and, frequently, a weakened relationship with school content, especially with mathematics (Freire, 1999). This discipline is often perceived as an obstacle to learning, due to accumulated conceptual gaps and the absence of methodologies that dialogue with their realities.

During pedagogical activities carried out in the Supervised Internship III in EJA Médio classes, it was possible to identify the students' interest in the use of technological resources, although difficulties persist related to the handling of digital devices, regular access to the internet and familiarity with educational platforms. These findings reveal limitations associated with school infrastructure, teacher training and digital inclusion, but also point to the potential of DICTs as mediators of mathematical learning. When used with pedagogical intentionality, DICTs can contribute to making the teaching of mathematics more accessible, visual and meaningful, as highlighted by Valente (2018), when he argues that educational technology should be articulated with pedagogical proposals that value the active participation of the student and the construction of knowledge.

This perspective is reinforced by Maietto (2025), when he argues that the integration of technologies into the teaching of mathematics in EJA can contribute to overcoming historical learning difficulties, as long as it is inserted in critical and inclusive pedagogical practices. Almeida; Oliveira (2023) also point out that mobile devices, such as smartphones and tablets, widely present in the daily lives of students, can be important allies in the teaching-learning process, when used in a planned and contextualized way.

In view of this scenario, this work aims to investigate how DICTs have been used in the adaptation of mathematical activities for EJA students in High School, analyzing theoretical productions, didactic materials and educational documents related to the theme. The research seeks to understand how these technologies are being incorporated into pedagogical practices and what limits and possibilities emerge from this process. The question that guides the study is: How have DICTs been used in the adaptation of mathematical activities for high school students, considering the pedagogical and technological challenges of this context? It is based on the hypothesis that, although there are initiatives that mention the use of DICTs, many of them still have difficulties in dialoguing with the concrete reality of public schools, especially with regard to infrastructure, teacher training and digital inclusion.

The relevance of this study is associated with the need to contribute to the construction of pedagogical practices that are more sensitive to the specificities of EJA students. When taught in a decontextualized way, mathematics can constitute an obstacle to learning; however,

when adapted with the support of DICTs and articulated with the students' experiences, it can become an instrument of empowerment, autonomy and social participation.

This work is structured in five sections: the first presents the introduction, with the theme, justification, problem, relevance, objective and structure of the study; the second section exposes the theoretical foundation; the third describes the methodological procedures; the fourth brings the proposal of activities adapted to EJA through the use of DICTs; and the fifth section presents the final considerations and suggestions for future practices.

2 THEORETICAL FRAMEWORK

This section presents the theoretical references that underlie the proposal of this work, which aims to investigate and propose adaptations of mathematics activities for EJA, mediated by the use of DICTs. Thus, it seeks to contribute to the construction of more inclusive, contextualized pedagogical practices that are sensitive to the specificities of students in this type of education.

The theoretical contributions mobilized allow us to understand mathematics education in EJA from a perspective that recognizes digital technologies not only as didactic resources, but as cultural and pedagogical elements capable of favoring the inclusion, autonomy and protagonism of the subjects, expanding the possibilities of meaningful learning.

2.1 YOUTH AND ADULT EDUCATION (EJA)

EJA is a modality of Basic Education aimed at guaranteeing the right to schooling of subjects who did not have access to or continuity of studies at the regular age, due to historical, social, economic and cultural factors. More than a space for school compensation or recovery, EJA is configured as an educational field marked by the diversity of trajectories, the plurality of life experiences and the need for pedagogical practices sensitive to the specificities of the students who compose it.

The EJA subjects bring with them stories of school interruptions, early insertion into the world of work, family responsibilities and experiences in contexts of social vulnerability. In this scenario, education assumes a strategic role in the reconstruction of life projects, in the valorization of knowledge built throughout social and professional experiences, and in the affirmation of historically marginalized identities. Thus, EJA demands pedagogical proposals that recognize the complexity of the subjects and promote significant and emancipatory formative processes.

Freire's (1997) critical pedagogy offers important foundations for understanding EJA as a space for dialogue, listening and collective construction of knowledge. By stating that "authentic education is not made of A to B or of A on B, but of A to B, mediated by the world" (Freire, 1997, p. 68), the author emphasizes the centrality of dialogical relations in the educational process, breaking with banking and transmissive practices. The so-called banking education consists of treating students as passive recipients of content, in a teaching model that deposits information without dialogue or problematization. This criticism is particularly relevant in EJA, as it recognizes students as active subjects, bearers of knowledge and experiences that must be considered in the teaching-learning process.

This perspective also dialogues with my own trajectory: graduated from a public school, with passages through technical and higher education courses interrupted, I experienced in practice the limits of an education that often does not dialogue with the realities of students. Like many EJA students, I had to reconcile work, family and studies, which reinforces the importance of a pedagogy that recognizes previous knowledge and values non-linear paths.

In his reflection on the ethical and political dimension of education, Freire (2002) highlights that educational practice must be committed to humanization and to overcoming oppressive relations, understanding education as a process of social transformation. In this sense, EJA assumes a political-pedagogical character by enabling young people and adults to appropriate knowledge as an instrument of critical reading of reality and conscious intervention in the world.

Gadotti (2000, p. 17) reinforces this perspective when he states that "educating is a political act. Every educational practice implies a conception of man and society". Also for Gadotti, EJA requires its own approach, which starts from the concrete experiences of students and recognizes their knowledge as a starting point for the construction of knowledge:

"Youth and adult education cannot be a simple reproduction of formal education for young people. It must be thought of from the needs, desires and experiences of the subjects who participate in it. It is an education that requires sensitivity, listening and commitment to social transformation." (Gadotti, 2000, p. 45)

From this perspective, EJA is not limited to the physical space of the classroom, but is configured as a territory of resistance, welcoming, and the production of meanings. Students who attend this modality are not only resuming interrupted schooling, but reconstructing formative trajectories and projecting new personal and professional horizons. Such understanding reinforces the need for pedagogical practices that dialogue with the daily lives of students, value their knowledge and promote contextualized and socially relevant learning.

From a legal and normative point of view, EJA is supported by the Federal Constitution of 1988, which ensures education as a right of all and a duty of the State, as well as in the National Common Curricular Base (BNCC), which recognizes the diversity of Basic Education subjects and the need for inclusive pedagogical practices (Brasil, 2018). In addition, recent studies, such as those by Freires et al. (2024), reinforce the importance of EJA in promoting educational equity and guaranteeing the right to lifelong education.

Thus, understanding Youth and Adult Education as a specific educational field implies recognizing its historical challenges and its formative potentialities. EJA requires pedagogical proposals committed to inclusion, dialogue and appreciation of the experiences of the subjects, constituting a fundamental space for the construction of a democratic, emancipatory and socially referenced education.

2.2 THE TEACHING OF MATHEMATICS IN YOUTH AND ADULT EDUCATION (EJA)

Teaching mathematics in EJA requires the articulation between school concepts and the concrete experiences of students, since these subjects mobilize mathematical knowledge in different daily practices, such as at work, in the organization of household finances and in time management. However, such knowledge is not always recognized as legitimate in the school space, which reinforces the need for pedagogical practices that value it as a starting point for the construction of more meaningful mathematical learning (Hirye; Higa; Altoé, 2023).

In this sense, ethnomathematics, proposed by D'Ambrosio (2005), offers important contributions to the understanding of mathematics teaching in EJA. By arguing that different cultures produce their own ways of thinking and doing mathematics, the author proposes an approach that values knowledge built in different sociocultural contexts. For D'Ambrosio (2005), mathematical ideas associated with processes such as comparing, classifying, quantifying, measuring and organizing are inherent to human nature and manifest themselves in multiple ways, and should be recognized as legitimate expressions of mathematical thought. This perspective contributes to breaking with homogeneous and universalizing conceptions of school mathematics, favoring more inclusive and contextualized pedagogical practices in EJA.

Complementing this view, Vygotsky's (1998) historical-cultural theory also offers relevant subsidies for the teaching of mathematics in this modality, by understanding learning as a socially mediated process. According to the author, the development of thought is directly related to social interactions and language, and knowledge is built in the relationship between subject and object, mediated by culturally shared signs and meanings. In the context of EJA, this approach reinforces the importance of pedagogical practices that promote interaction,

dialogue and collaboration, enabling students to build mathematical knowledge from the exchange of experiences and teacher mediation.

From this perspective, mathematical learning in EJA must be meaningful and connected to the students' reality, as defended by Maietto (2025). The author argues that the use of digital resources, such as videos, games and simulators, can contribute to overcoming historical learning difficulties, as long as these tools are integrated with critical and inclusive pedagogical proposals. Such proposals are not limited to the instrumental use of technology, but seek to promote active participation, question inequalities and value the knowledge of students, recognizing their trajectories and experiences.

For Maietto (2025), the use of digital technologies in mathematics teaching should not be restricted to the reproduction of content, but favor dialogue, the collective construction of knowledge and the appreciation of students' knowledge, promoting greater autonomy and engagement. This reflection dialogues with my own experience: when working with technology and logistics, I realized that the use of simulators and software not only reproduces information, but allows you to understand processes in a practical and contextualized way — the same as what is expected in teaching mathematics to EJA.

Gonçalves et al. (2017) corroborate this understanding by highlighting that digital technologies can play a significant role in making classes more dynamic and expanding the possibilities of expression for EJA students:

"The use of technological resources, when well planned, can favor the autonomy of students, expand their possibilities of expression and promote more meaningful learning, especially in the context of EJA, where students bring with them diverse experiences and knowledge built outside the school environment." (Gonçalves et al., 2017, p. 147)

In the context of educational policies and materials, the didactic material structured by the Department of Education of the State of Ceará (SEDUC-CE), in 2023, presents proposals organized around problem solving and student protagonism. Although it does not directly explain the use of digital technologies, its pedagogical structure favors adaptations to digital environments, allowing the teacher to incorporate explanatory videos (such as Khan Academy and YouTube Edu), simulators (such as GeoGebra and PhET) and interactive platforms (such as Moodle and Google Classroom), expanding the possibilities of teaching and learning mathematics in EJA.

Thus, the teaching of mathematics in EJA should be understood as a process that articulates school knowledge and everyday knowledge, promoting the construction of contextualized and socially relevant knowledge. In this scenario, Digital Information and

Communication Technologies (DICTs) emerge as potential allies, as long as they are integrated with critical pedagogical proposals, mediated by the teacher and committed to valuing students' experiences. Resignifying the teaching of mathematics in EJA implies, therefore, recognizing the subjects as protagonists of their learning and building educational practices that dialogue with their realities, life projects and with the demands of society, which require mathematical skills applied to the world of work, citizenship and daily life.

Finally, it is necessary to consider that, although mobile devices such as smartphones and tablets are widely present in the daily lives of students and offer great pedagogical potential (Almeida; Oliveira, 2023), many institutions maintain restrictions on their use in the classroom. In this context, it is up to the teacher to seek regulated alternatives, such as computer labs or institutional tablets, ensuring that technology is used in a pedagogical way and not just recreationally.

2.3 DIGITAL INFORMATION AND COMMUNICATION TECHNOLOGIES (TDICS) IN EDUCATION

DICTs have caused significant transformations in the ways of teaching, learning and producing knowledge, directly influencing contemporary pedagogical practices. In the educational context, such technologies go beyond the function of mere technical instruments, configuring themselves as cultural elements that restructure forms of interaction, communication and construction of knowledge. In EJA, DICTs play a strategic role in promoting educational inclusion, personalizing learning, and valuing students' life experiences.

In the context of mathematics teaching, studies indicate that the use of digital resources can favor the visualization of abstract concepts, expand student participation and recognize the knowledge built outside the school space. When intentionally integrated into pedagogical planning, DICTs contribute to more meaningful practices, enabling students to take an active role in the learning process, strengthening their autonomy and protagonism.

Valente (2018) highlights that the pedagogical potential of DICTs is directly related to the teacher's ability to use information about student performance to readjust teaching methods and instruments, promoting the personalization of learning. This idea resonates with my professional experience: when working with logistics and technology, I realized that systematic data monitoring is essential to adjust processes and achieve better results. Similarly, in education, the use of DICTs can allow teachers to personalize teaching according to the needs of each student.

This perspective is reinforced by Kenski (2012), when he states that educational technology is not neutral, as it carries values, intentionalities and worldviews. This reflection is close to my formative path: when dealing with technological systems, I realized that each tool brings with it its own logic and requires a critical posture from the user. In the teaching of mathematics in EJA, this means that the teacher must be aware not only of the technical use of DICTs, but also of the social and cultural implications they carry.

Moran (2007) complements this debate by understanding education as a process of construction of meanings, values and competencies for life in society. According to the author, digital networks make it possible to organize teaching in a more dynamic, active and flexible way. This vision connects with my academic experiences: when I returned to the area of mathematics after experiences in other courses, I realized that flexibility and personalization are essential for the student to be able to reconcile study, work and personal life — a reality common to EJA students.

Fiuza (2015) expands this discussion by arguing that DICTs should be understood as learning environments, and not just as complementary resources. For the author, such technologies require new pedagogical postures, new forms of interaction and different ways of thinking about the curriculum, especially in the context of EJA, in which the promotion of digital inclusion and student autonomy is a central challenge. This reflection is also confirmed in my professional practice: when working with technology, I realized that digital environments are not accessories, but central spaces for learning and interaction.

With regard to the teaching of mathematics in EJA, Almeida; Oliveira (2023) highlight the role of mobile devices, such as smartphones and tablets, as they are widely inserted in students' daily lives. The authors argue that the use of applications, videos and digital games can favor the visualization of abstract mathematical concepts, stimulate student engagement and expand the possibilities of communication between teacher and student, including outside the classroom space. However, it is necessary to recognize that many institutions still maintain restrictions on the use of smartphones in the classroom, which imposes limits on their pedagogical application. In this scenario, it is up to the teacher to seek regulated alternatives, such as computer labs, institutional tablets or supervised digital platforms, ensuring that technology is used in a pedagogical and not just recreational way.

Corroborating this perspective, Maietto (2025) argues that the integration of DICTs into EJA should be associated with critical and inclusive pedagogical proposals, which go beyond the simple reproduction of content. For the author, the use of technologies should provide opportunities for dialogue, the collective construction of knowledge and the appreciation of

students' knowledge, contributing to overcoming historical difficulties in the teaching of mathematics in this modality. This idea is also connected to my academic career: when I returned to mathematics after experiences in other areas, I realized that knowledge only becomes meaningful when it dialogues with the concrete reality of the subjects and their social needs.

Thus, the presence of DICTs in EJA should not be understood as an accessory or occasional resource, but as a pedagogical need in the face of contemporary teaching and learning demands. When used in a planned and critically mediated way by the teacher, these technologies can increase student engagement, favor the understanding of mathematical concepts, and strengthen student protagonism, contributing to more inclusive, contextualized, and meaningful pedagogical practices.

3 METHODOLOGICAL PROCEDURES

The present research is characterized as a bibliographic and documentary study, with a qualitative approach and propositional-pedagogical character, whose objective was to investigate how Digital Information and Communication Technologies (DICTs) have been used in the adaptation of mathematical activities in the context of Youth and Adult Education (EJA), specifically in High School. In addition to the theoretical analysis, the study culminated in the elaboration of a didactic activity adapted and mediated by TDICs, understood as an educational product of the research.

The bibliographic survey was carried out through systematized searches in academic databases and repositories, selected for their relevance in the dissemination of scientific production in the areas of Education, Mathematics Education and Educational Technologies, during the period from 2016 to 2025. SciELO (Scientific Electronic Library Online) was consulted, as it is one of the main open access electronic libraries in Latin America and brings together high-quality scientific journals in Portuguese and Spanish; Google Scholar, for its scope and ability to index articles, theses, dissertations and books from different areas; CAPES Periodicals, for bringing together national and international reference journals and ensuring access to up-to-date studies and scientific credibility; and institutional repositories, such as those of the Federal University of Ceará and IFCE, which provide dissertations, theses and academic works directly related to the local reality and the EJA modality. The choice of these databases is justified by the need to ensure diversity of sources, geographic coverage and scientific reliability, contemplating both international and national and regional productions.

The searches were performed with descriptors combined with Boolean operators, in order to expand and refine the results. The expressions used included, in isolation and combination: "Youth and Adult Education" OR "EJA"; "mathematics teaching" AND "digital technologies"; "teaching mathematics" AND "TDICs"; "EJA" AND "teaching mathematics" AND ("TDICs" OR "educational technologies"); "Youth and Adult Education" AND "digital inclusion". To delimit the scope, exclusion operators were used, such as NOT "Higher Education", NOT "Early Childhood Education" and NOT "Elementary Education", ensuring that the results remained focused on the EJA modality of High School.

The selection of productions was based on previously defined criteria, ensuring methodological rigor and relevance to the object of study. Studies that addressed the use of DICTs in the educational context, productions related to the teaching of mathematics, research that contemplated the EJA modality, works published in Portuguese and publications with theoretical and pedagogical relevance to the analysis were included. Studies that dealt with the use of technologies in a merely instrumental way, without pedagogical problematization, were excluded; research focused exclusively on other stages or modalities of teaching, such as Early Childhood Education, Elementary Education or Higher Education; duplicate jobs; and productions that did not have a direct relationship with the teaching of mathematics in EJA.

After applying these criteria, a corpus was constituted consisting of six studies, systematized in Table 1.

Table 1

Synthesis of the empirical/applied corpus (EJA + Mathematics + DICT)

Author(s) / Year	Type	TDIC(s)	Contents Mathematician	Objective of the study	Main contributions to EJA
Bohrer & Tinti (2021)	Article	GeoGebra on smartphon and	Quadratic function	Investigate difficulties of EJA students when using GeoGebra on their cell phones in activities About quadratic function	It highlights obstacles to use/operationalization and points out the need for teacher mediation and digital literacy to ensure learning with mobility
Santiago (2025)	Article	Augmented Reality (AR)	Geometric Solids	To analyze the impact of AR on the teaching of geometric solids in EJA	Shows AR potential for 3D visualization and engagement; reinforces the importance of planning and conditions of use for Effectiveness
Olive (2023)	Article	Kahoot!	Emphasis Posted on Evaluative Practice/Quiz	Discuss how Kahoot! can assist teachers in EJA	Indicates gain of participation and immediate feedback; suggests use as a strategy for formative assessment and motivation

Monteiro & de Martini (2025)	Work/Report (repository)	Kahoot!	Probability	Analyze the use of Kahoot in the teaching of probability in EJA	It proposes a gamified approach to abstract content; points to potential for logical reasoning and participation, with attention to infrastructure
Silva (2022)	Article	PhET (simulator "Area Constructor")	Area and perimeter	Present the importance of teaching PhET-mediated area/perimeter in EJA	It suggests greater autonomy and learning by exploration/simulation; reinforces the role of the teacher in conducting and problematizing
Araújo (2024)	Scientific Article	Geogebra	Flat geometry	Articulate geometry teaching in EJA with the use of Geogebra	It reinforces the potential of digital resources for concept formation and visualization, with the need for pedagogical intentionality

Source: Authors (2025)

The analysis of the selected studies showed that the use of DICTs in the teaching of Mathematics in EJA does not occur in a homogeneous way, assuming different pedagogical functions according to the didactic objectives, the mathematical contents and the educational context. In view of this, the works were organized into four analytical categories, defined from the literature of Mathematics Education and the recurrence of meanings attributed to DICTs in the analyzed texts.

3.1 C1 – TDICS AS A RESOURCE FOR VISUALIZATION AND CONCEPTUAL CONSTRUCTION

This category brings together studies in which DICTs act primarily as means of mathematical visualization, enabling the dynamic exploration of algebraic, geometric and graphic representations. This perspective dialogues with D'Ambrosio (2005), who recognizes that different cultures produce their own ways of thinking and representing mathematics, and with Valente (2018), who highlights the potential of technologies to personalize learning. In EJA, in which many students have difficulties with formal abstractions, resources such as GeoGebra and PhET favor conceptual construction and autonomy, bringing school knowledge closer to concrete practices.

3.2 C2 – TDICS AS A GAMIFICATION, INTERACTION AND ENGAGEMENT STRATEGY

Category C2 comprises studies that attribute to DICTs a predominantly motivational and interactive function, associated with student engagement, participation in collective activities and formative assessment. This approach is supported by the historical-cultural theory of Vygotsky (1998), when he emphasizes that learning takes place in social interaction mediated

by signs, and also in Moran (2007), who defends dynamic and flexible pedagogical practices. Tools like Kahoot! they promote collective participation and immediate feedback, resignifying the relationship of EJA students with mathematics and strengthening student protagonism.

3.3 C3 – TDICS FOR CONTEXTUALIZATION OF MATHEMATICS IN THE DAILY LIFE OF EJA

Category C3 groups the studies in which DICTs are used as a bridge between mathematical knowledge and the social, professional and daily reality of EJA students. This perspective dialogues directly with Freire's (1997; 2002) critical pedagogy, by valuing the students' previous knowledge and promoting a critical reading of reality. It is also close to the reflections of Maietto (2025), who defends the use of technologies in critical and inclusive proposals. In this sense, DICTs favor contextualized and socially relevant learning, allowing students to relate mathematics to their work practices, finances, and the organization of daily life.

3.4 C4 – LIMITATIONS AND CHALLENGES IN THE USE OF TICS IN EJA

Unlike the previous categories, C4 does not refer to a specific pedagogical function, but to the conditions for the implementation of DICTs in the context of EJA. This category emerges in a transversal way in the corpus, evidencing structural, pedagogical and formative challenges. The reflections of Kenski (2012) and Fiuza (2015) help to understand such limits, by highlighting that educational technology is not neutral and requires new pedagogical postures and adequate conditions of use. Issues such as precarious infrastructure, restriction on the use of smartphones in the classroom and the need for teacher training reveal that the potential of DICTs is only realized when there is pedagogical intentionality and policies that ensure digital inclusion.

Table 2 summarizes the authors analyzed and the analytical categories to which their work was associated.

Table 2

Synthesis of the analyzed corpus and analytical categorization

Author(s) / Year	Type of study	Background	TDIC(s)	Mathematical content	Category(s)
Bohrer & Tinti (2021)	Article Scientific	EJA	GeoGebra	Function Quadratic	C1, C4
Silva (2022)	Article Scientific	EJA	PhET	Area and Perimeter	C1, C3
Olive (2023)	Article Scientific	EJA	Kahoot	Evaluation Mathematics	C2, C4
Araújo (2024)	Article	EJA	Geogebra	Geometry	C1, C3

	Scientific			flat	
Santiago (2025)	Article Scientific	EJA	Reality Increased	Geometry space	C1, C4
Monteiro & De Martini (2025)	Experience report	EJA	Kahoot	Probability	C2, C3

Source: Authors (2025)

From the analysis organized by the analytical categories and in dialogue with the theoretical references, didactic activities adapted with the use of DICTs were elaborated, directed to the teaching of mathematics in EJA – High School. It is noteworthy that, as this is a bibliographic and documentary research, the results do not allow empirical generalizations about the application of DICTs in specific school contexts. Therefore, the need for future empirical investigations, such as case studies or action research, which deepen the analysis of the impact of these practices on the mathematical learning of EJA students, is indicated.

3.5 DIDACTIC ACTIVITIES ADAPTED WITH TDICS IN THE TEACHING OF MATHEMATICS IN EJA

The construction of these activities is based on the understanding that EJA has its own specificities, such as the heterogeneity of the classes, the interrupted school trajectories, the conceptual gaps accumulated throughout the training path and the need to value the knowledge built in the social and professional daily life of the students. In this context, DICTs are understood not only as technical tools, but as cultural artifacts that mediate new ways of thinking, teaching and learning mathematics.

The process of preparing the proposals followed stages articulated between theory and practice. First, the categories identified in the research corpus (conceptual visualization, gamification, contextualization and challenges) were analyzed, in order to understand how different digital resources can contribute to the teaching of mathematics in EJA. Next, we sought to dialogue with the theoretical references: the valorization of previous knowledge and the critical reading of reality, according to Freire (1997; 2002); the importance of social interaction and teacher mediation, according to Vygotsky (1998); and the potential of technologies to personalize and streamline learning, as advocated by Valente (2018), Kenski (2012) and Moran (2007).

From this dialogue, criteria were defined for the construction of the activities: pertinence to the EJA context, integration of DICTs as mediators, pedagogical intentionality, appreciation of student autonomy and practical feasibility in the face of the real conditions of the schools.

Activity 01: Percentage and financial planning with the use of Kahoot

Mathematical content: Percentage, calculation of discounts and analysis of price variations.

Digital tool: *Kahoot*

Category(s): C2 (gamification and engagement), C3 (contextualization)

3.5.1 Objectives of the activity

- Understand the concept of percentage from real everyday situations;
- Develop mathematical reasoning applied to financial planning and organization;
- To promote critical reflection on consumption practices and financial decision-making.
- Stimulate student participation, engagement, and protagonism through gamification.

3.5.2 Description of the activity

The activity consists of the elaboration of an interactive quiz on the Kahoot platform, structured from problem situations related to the daily financial planning of EJA students. The questions involve contexts such as discounts on purchases, commercial promotions, price comparison, salary adjustments and organization of monthly expenses, favoring the articulation between the mathematical content and the social reality of the students.

The problem situations are presented in accessible and contextualized language. For example:

In this case, the students calculate the final value of the product (R\$ 900.00) and discuss whether or not the purchase compromises the monthly budget. In addition to the mathematical calculation, they are encouraged to reflect on the relevance of the financial decision, expanding the formative meaning of the activity. The teacher can propose variations, such as different budget amounts or fixed expenses (rent, food, transportation), stimulating critical analysis and conscious decision-making.

The application can take place individually or in groups, using the students' own mobile devices or with the projection of the questions in the classroom, enabling collective participation, the exchange of resolution strategies and the socialization of mathematical and financial reasoning built throughout the activity.

3.5.3 Critical analysis of the proposed activity

The activity highlights the potential of DICTs to integrate the teaching of Mathematics with financial planning, a central aspect in the training of young people and adults. The pedagogical analysis of the activity shows that the use of Kahoot contributes to making the

learning process more dynamic and motivating, a relevant aspect in EJA, where many students have experiences of school failure in mathematics. Oliveira (2023) highlights that the platform expands participation and provides immediate feedback, while Monteiro & De Martini (2025) reinforce its potential to engage students in financial mathematics content.

From a conceptual point of view, the activity favors meaningful learning, as defended by Ausubel (2003), by relating mathematical concepts to real consumption practices, financial organization and decision-making. In addition, it dialogues with Critical Mathematics Education, by stimulating reflection on financial choices and their impacts on daily life, as proposed by Skovsmose (2001).

However, the activity also has limitations, especially with regard to the dependence on mobile devices and internet access, which may restrict its application in contexts marked by precarious technological infrastructure, as pointed out in category C4. In addition, the playful character of the platform requires careful pedagogical mediation, so that the competitive dynamics do not override the conceptual reflection. In this sense, the role of the teacher is central, by promoting moments of collective discussion, analysis of errors and problematization of results, ensuring that technology is used in a critical, reflective and contextualized way.

Although the contents covered in this activity can be worked on through traditional methodologies, such as the use of the whiteboard in the classroom, the use of technology increases engagement, favors immediate feedback, reduces mathematical anxiety, and enhances the contextualization of financial planning, aspects that are particularly relevant in the context of EJA (Moran; Bacich, 2018; Borba; Silva; Gadanidis, 2016).

Activity 02: Spatial geometry using the AR Solids app **Mathematical content:** Volume and area of geometric solids **Digital tool:** AR Solids – Augmented Reality

Category(s): C1 (visualization and conceptual construction), C3 (contextualization)

3.5.4 Objectives of the activity

- Understand concepts of area and volume of geometric solids through augmented reality visualization;
- Relate spatial geometry to real everyday situations (reservoirs, boxes, buildings);
- Stimulate the protagonism of students and collaborative work;
- Develop digital skills applied to the teaching of mathematics.

3.5.5 Description of the activity

The activity consists of using the AR Solids application to view and manipulate three-dimensional models of geometric solids in augmented reality. Students, using their smartphones, can project the solids on the classroom table and interact with them, observing dimensions, faces, vertices and edges.

The professor proposes contextualized situations, such as: "A water reservoir has a cylindrical shape with a radius of 2 meters and a height of 3 meters. What is the volume of this reservoir m³?". Students, by manipulating the cylinder in the application, can better understand its dimensions and relate the mathematical formula to the visualized object.

The activity can be carried out in groups, stimulating collaboration. Each group chooses a solid, explores its characteristics in the application, and solves practical problems involving area and volume calculation. At the end, the groups share their findings with the class, promoting the socialization of mathematical reasoning.

3.5.6 Critical analysis of the proposed activity

The use of augmented reality (AR) in the teaching of Geometry favors three-dimensional visualization and conceptual construction, an aspect highlighted by Santiago (2025), by highlighting the potential of this technology to overcome barriers related to spatial abstraction and expand the engagement of students in Youth and Adult Education. This contribution dialogues with the discussions of Borba, Silva and Gadanidis (2016), who argue that digital environments expand the forms of mathematical representation and transform the relationship of students with knowledge, favoring processes of experimentation and visual exploration.

By shifting the teaching of geometry to practical situations, such as the calculation of reservoir volumes or the analysis of everyday objects, the activity reinforces the contextualization of Mathematics (C3), bringing mathematical concepts closer to the social and professional experiences of EJA students. This perspective is supported by Critical Mathematics Education, as proposed by Skovsmose (2008), when understanding Mathematics as an instrument for reading reality and making decisions in concrete contexts.

Kenski (2012) points out that emerging technologies, such as augmented reality, can increase student interaction and involvement, as long as they are integrated with clear didactic objectives and mediated intentionally. In this sense, AR should not be understood only as a visual resource, but as a tool for problematizing and constructing mathematical meanings.

However, the activity also has important limitations (C4). Its implementation depends on access to compatible mobile devices and an adequate technological infrastructure, which can

restrict its application in contexts marked by the digital divide. In addition, as Santiago (2025) warns, the absence of critical pedagogical mediation can lead students to a merely visual exploration, disconnected from the necessary mathematical formalization. Thus, the role of the teacher becomes central, as it guides the articulation between visual observations, mathematical calculations and concrete situations, ensuring that technology fulfills a critical, reflexive and socially contextualized pedagogical function, and not just an illustrative one.

Activity 03: Exploration of polygons and calculation of areas with GeoGebra

Mathematical content: Area and perimeter of plane figures

Digital tool: GeoGebra (2D version)

Category(s): C1 (visualization), C3 (contextualization)

3.5.7 Objectives of the activity

- Understand concepts of area and perimeter of plane figures;
- Relate plane geometry to practical everyday situations;
- Develop digital skills applied to the teaching of mathematics;
- Stimulate protagonism and collaborative work among students.

3.5.8 Description of the activity

The activity consists of using GeoGebra to build flat geometric figures and calculate their areas and perimeters. Students, in pairs or groups, draw triangles, squares, rectangles and circles in the app, adjusting measurements of sides and radii.

The teacher proposes contextualized situations, such as: "A square has a square shape with 20 meters on a side. What is its area and perimeter?" Students build the figure in GeoGebra, enter the measurements and verify the calculations.

Then, each group chooses a different picture and creates practical problems related to everyday life, such as calculating the area of a plot of land, the perimeter of a fence or the area of a round table. The results are socialized with the class, promoting the exchange of reasoning and resolution strategies.

3.5.9 Critical analysis of the proposed activity

The use of GeoGebra in the exploration of polygons and in the calculation of areas and perimeters favors the dynamic visualization of geometric objects, an aspect widely discussed in the literature of Mathematics Education. Bohrer and Tinti (2021) show that the direct

manipulation of geometric figures in digital environments contributes to overcoming recurrent abstraction difficulties among Youth and Adult Education students, by enabling the articulation between graphic representation, symbolic language, and conceptual interpretation. This characteristic reinforces the C1 category, by allowing students to explore geometric properties in an active and investigative way.

This perspective is supported by the contributions of Borba, Silva and Gadanidis (2016), who argue that digital environments expand the forms of production of mathematical knowledge, favoring processes of experimentation, conjecture and validation. In the case of EJA, such environments play an even more relevant role, as they allow students to reconstruct mathematical concepts from the interaction with visual and manipulable representations, reducing the exclusive dependence on abstract formulas.

From a pedagogical point of view, the activity shifts the teaching of plane geometry from mechanical and decontextualized practices to real everyday situations, such as calculating the area of land, squares or objects of daily use. This approach reinforces the contextualization of Mathematics (C3), a central principle of EJA, by valuing the social and professional experiences of students. Araújo (2024) highlights that the intentional use of GeoGebra in EJA favors the formation of geometric concepts when associated with contextualized problems, in which the student understands the social function of mathematical knowledge.

This articulation between visualization and context also dialogues with Critical Mathematics Education, proposed by Skovsmose (2008), by understanding Mathematics as an instrument to interpret and act in reality. By solving problems related to physical spaces and organization of the environment, students begin to perceive geometry as a tool for practical decision-making, expanding the social sense of learning.

However, the activity also has limitations (C4): it requires access to computers or cell phones with the application, which may be restricted in some EJA contexts, in addition to demanding digital literacy from students. It is necessary for the teacher to carry out careful mediation, ensuring that students do not limit themselves to observing the figures, but understand the mathematical concepts involved and are able to apply them in real situations. Thus, the role of the teacher is central to guiding research, promoting conceptual reflection, and ensuring that students understand not only the visual representation of the figures, but the underlying mathematical concepts and their applications in real-world situations.

Activity 04: Simulation of financing and investments with HP12C Mobile **Mathematical content:** Simple and compound interest, present value and future value **Digital tool:** HP12C

Mobile (financial calculator in digital version) **Category(s):** C3 (contextualization), C4 (limitations)

3.5.10 Objectives of the activity

- Understand concepts of simple and compound interest, present value and future value;
- Relate financial mathematics to personal and professional decisions;
- Develop autonomy in the use of digital applications applied to mathematics;
- Stimulate critical reflection on consumption, credit and financial planning.

3.5.11 Description of the activity

The activity consists of using the HP12C Mobile application to simulate real financing and investment situations. Students, in groups, receive contextualized problems, such as:

- "A loan of R\$ 1,000.00 will be paid in 12 installments with interest of 2% per month. What will be the total amount paid?"
- "An investment of R\$ 500.00 applied to compound interest of 1.5% per month for 24 months will have what future value?"

Students enter the data into the app (present value, interest rate, number of periods) and check the results. Then, they discuss the practical implications of these operations, relating them to everyday situations, such as installment purchases, bank loans or savings.

The activity can be carried out in the classroom with smartphones or designed by the teacher, allowing everyone to follow the calculations. After each simulation, the teacher conducts a collective discussion about the results and encourages students to reflect on the advantages and disadvantages of each financial operation.

3.5.12 Critical analysis of the proposed activity

The use of HP12C Mobile in the teaching of financial mathematics makes it possible to bring concepts such as simple and compound interest, present value and future value closer to the daily reality of EJA students, allowing the simulation of concrete credit, financing and investment situations. This approach reinforces the contextualization of Mathematics (C3), by shifting teaching from abstract exercises to real problems related to consumption, financial organization, and personal and professional decision-making. Araújo (2024) highlights that the intentional use of digital technologies favors the formation of mathematical concepts when articulated with meaningful contexts for EJA students.

This activity dialogues with Skovsmose (2008), when he understands Mathematics as a tool to interpret and intervene in social reality. By simulating financing and investments, students are led to reflect on the economic consequences of financial decisions, developing a more critical posture in the face of consumption, indebtedness and financial planning practices. This dimension is particularly relevant in EJA, whose students often deal with complex financial situations in their daily lives.

From a didactic point of view, the use of digital financial calculators can contribute to reducing the operational load of calculations, allowing the focus of learning to fall on the interpretation of the results and the analysis of the conditions involved in each operation. Borba, Silva and Gadanidis (2016) argue that digital environments can enhance mathematical learning when they shift attention from mechanical procedure to conceptual understanding and informed decision-making.

However, the activity also has relevant limitations (C4). The use of the HP12C Mobile presupposes access to compatible smartphones and a minimum level of digital literacy. In addition, as Kenski (2012) warns, the uncritical use of technologies can reduce teaching to an automation of procedures, if there is no adequate pedagogical mediation. In this sense, it is up to the teacher to promote collective discussions that problematize the results obtained, ensuring that students understand the mathematical concepts underlying financial operations and their social and economic implications.

Thus, the teaching role assumes centrality in the conduction of the activity, by articulating the use of technology with critical reflection, ensuring that the HP12C Mobile fulfills a pedagogical function that goes beyond the execution of calculations, contributing to the formation of more autonomous and conscious subjects in relation to financial decisions.

Activity 05: Fractions in everyday life with the PhET Fractions simulator

Mathematical content: Equivalent fractions, addition and multiplication of fractions

Digital tool: PhET Fractions (interactive simulator)

Category(s): C1 (visualization), C3 (contextualization), C4 (limitations)

3.5.13 Objectives of the activity

- Favor the understanding of the concepts of equivalent fractions and basic operations with fractions;
- Relate the study of fractions to practical situations of the daily life of EJA students;

- Promote student autonomy and protagonism in the use of digital resources applied to Mathematics;
- Stimulate multimodal learning, articulating visual, practical and interactive aspects.

3.5.14 Description of the activity

The activity consists of the use of the PhET Fractions simulator, which enables the visual and interactive representation of fractions through familiar objects, such as pizzas, fractional bars and containers, favoring the understanding of the concepts of equivalence, addition and multiplication of fractions.

Initially, the teacher presents a contextualized problem-situation, such as:

*"A recipe uses $\frac{2}{3}$ of a glass of milk. If the recipe is prepared in double quantity, what will be the total amount of milk needed?"*element. The students represent the fraction in the simulator, double the quantity and visually and numerically verify the result obtained, articulating graphic and symbolic representation.

Then, organized in groups, students receive contextualized challenges related to daily life, such as the division of household expenses, the apportionment of electricity bills, the distribution of construction materials or the calculation of fractions of the salary. The situations are solved with the support of the simulator and later socialized with the class, promoting the exchange of strategies, mathematical argumentation and the collective construction of knowledge.

3.5.15 Critical analysis of the proposed activity

Silva (2022) points out that the use of digital simulators favors the autonomous exploration of mathematical concepts, contributing to meaningful learning by articulating multiple forms of representation. Such potential reinforces the C1 category, as it allows students to understand fractions not only as abstract symbols, but as visually perceptible quantitative relations.

In addition, studies such as that of Lopes Júnior (2017) show that students in Youth and Adult Education face conceptual difficulties in the study of fractions, often associated with the lack of contextualization of activities and the predominance of abstract symbolic representations. In this sense, Borba, Silva and Gadanidis (2016) state that digital environments expand the possibilities of producing mathematical meanings through experimentation, manipulation and validation of conjectures, configuring themselves as relevant strategies for overcoming these difficulties.

From a didactic point of view, the activity shifts the teaching of fractions of mechanical and decontextualized exercises to real everyday situations, such as cooking, dividing expenses or organizing the family budget, reinforcing the contextualization of Mathematics (C3) and dialoguing with Skovsmose (2008), by understanding Mathematics as an instrument to interpret and act on social reality, favoring conscious decision-making.

In addition, the articulation between students' previous experiences and new mathematical concepts is close to the concept of meaningful learning, defended by Ausubel (2003), by enabling new knowledge to be anchored in existing cognitive structures, giving greater meaning to the learning process.

However, the activity also has important limitations (C4). Its implementation depends on access to the internet and compatible digital devices. Furthermore, as Kenski (2012) and Silva (2022) warn, the use of digital simulators requires intentional pedagogical mediation, so that students are not limited to the visual manipulation of objects, but understand the underlying mathematical concepts and are able to transfer them to real situations. In this sense, the role of the teacher is central to guide research, promote conceptual reflection and ensure that technology fulfills a critical, reflective and socially contextualized pedagogical function.

In summary, the analysis of the five proposed activities shows that the use of DICTs in EJA should be understood as a structuring pedagogical component, and not just as an accessory resource. The analytical categories C1 to C4 allow the identification of different functions of DICTs in the teaching of Mathematics in EJA.

Within the scope of the C1 category, tools such as GeoGebra, PhET Fractions and augmented reality expand the visualization of abstract mathematical concepts, favoring conceptual construction through multiple representations. Category C2 shows that gamification strategies, such as the use of Kahoot, contribute to the engagement and active participation of students, as long as they are articulated with clear pedagogical objectives. Category C3, on the other hand, reveals the potential of DICTs for the contextualization of Mathematics, especially in situations related to financial planning and the resolution of everyday problems, giving greater social meaning to learning.

However, category C4 explains important limitations, such as dependence on technological infrastructure, unequal access to technologies, and the need for digital literacy. These challenges reinforce that the use of DICTs requires intentional pedagogical mediation, as well as investments in digital inclusion policies and teacher training.

4 RESULTS AND DISCUSSIONS

The analysis of the bibliographic and documentary corpus allowed us to identify that the use of Digital Information and Communication Technologies (DICTs) in the teaching of Mathematics in Youth and Adult Education (EJA) has been developed progressively and associated, above all, with the need to make mathematical content more accessible, contextualized and meaningful for students. The studies analyzed show that DICTs do not only act as technical support tools, but as mediators of new forms of interaction, visualization and construction of mathematical knowledge, especially in contexts marked by interrupted school trajectories and historical learning difficulties.

The results indicate that DICTs contribute significantly to the visualization and understanding of abstract mathematical concepts, a recurrent aspect in the analytical category C1. Tools such as GeoGebra, PhET Fractions and Augmented Reality applications have demonstrated potential to favor conceptual construction through the dynamic manipulation of figures, graphs and three-dimensional representations. In this context, the studies by Bohrer and Tinti (2021), Silva (2022) and Santiago (2025) point out that visual exploration enables EJA students to understand concepts traditionally considered complex, such as quadratic functions, spatial geometry and equivalent fractions. Such results dialogue with Borba, Silva and Gadanidis (2016), when they argue that digital environments expand the forms of production of mathematical knowledge through experimentation and investigation.

In addition to conceptual visualization, the results demonstrate that DICTs favor student engagement and active participation in Mathematics classes, especially when associated with gamification and collective interaction, as identified in category C2. The use of Kahoot!, for example, showed potential to increase student participation, reduce math anxiety, and provide immediate feedback during activities. The works of Oliveira (2023) and Monteiro and De Martini (2025) reinforce that gamified strategies can contribute to resignifying the relationship of EJA students with Mathematics, making the learning process more dynamic and motivating. From the perspective of Vygotsky (1998), these results show the importance of social interaction and pedagogical mediation in the construction of knowledge, especially in collaborative contexts mediated by digital technologies.

Another relevant aspect identified in the results refers to the contextualization of Mathematics in the daily life of EJA students, a predominant characteristic in category C3. The activities involving financial planning, interest calculations, geometry applied to the urban space and division of household expenses showed that DICTs can bring mathematical content closer to the concrete experiences of the students. In this sense, the analyzed proposals reinforce the

understanding that mathematical learning becomes more meaningful when articulated with the social, professional and financial practices experienced by students. This perspective is close to Freire's (1997; 2002) critical pedagogy, when he argues that the educational process must start from the concrete reality of the subjects and promote a critical reading of the world.

The results also showed that the use of DICTs favors the development of student autonomy and protagonism. In several activities analyzed, students took an active role in problem solving, in the exploration of simulators and in the collective construction of mathematical strategies. This characteristic reinforces Moran's (2007) understanding that digital technologies can contribute to more flexible, dynamic and student-centered pedagogical practices. In EJA, this aspect takes on even greater relevance, considering that many students return to school seeking intellectual autonomy, professional qualification and strengthening of their social participation.

However, the results also reveal significant limitations related to the implementation of DICTs in the context of EJA, as evidenced in category C4. Among the main challenges identified are the precariousness of the technological infrastructure, the limitation of access to the internet, the insufficiency of digital equipment and the gaps in teacher training for the pedagogical use of technologies. Such difficulties were recurrent in the studies analyzed, especially in the studies that used mobile applications and digital platforms dependent on constant connection. These findings corroborate the reflections of Kenski (2012) and Fiuza (2015), when they emphasize that the pedagogical potential of technologies depends directly on the material, institutional and formative conditions that sustain their use.

Another point discussed in the studies refers to the need for critical pedagogical mediation in the use of DICTs. The results indicate that the simple insertion of digital technologies does not guarantee, by itself, meaningful learning or transformation of pedagogical practices. In several situations, the authors warn that the instrumental or decontextualized use of technologies can reproduce traditional and transmissive practices, limiting the emancipatory potential of DICTs. Thus, the role of the teacher emerges as a central element in the process of technological integration, being responsible for problematizing the contents, guiding interactions and articulating digital resources to the pedagogical objectives of EJA.

The discussion of the results shows, therefore, that DICTs have relevant potential to transform the teaching of Mathematics in EJA, especially by favoring conceptual visualization, contextualization of contents, student engagement and student protagonism. However, the benefits observed depend on structural and pedagogical factors that go beyond simple access to digital tools. The effectiveness of these technologies is directly related to teacher training,

infrastructure conditions, and the construction of critical, inclusive, and contextualized pedagogical proposals.

Finally, the results allow us to understand that the integration of DICTs to the teaching of Mathematics in EJA is a promising path for the construction of more democratic and socially significant pedagogical practices. However, for this potential to materialize, it is necessary to expand digital inclusion policies, strengthen the continuing education of teachers and ensure adequate material conditions for the pedagogical use of technologies in public schools. Thus, the findings of this research reinforce that DICTs, when articulated with a critical and emancipatory perspective of education, can contribute significantly to overcoming the historical difficulties of EJA and to the construction of more participatory, contextualized and transformative learning processes.

5 CONCLUSION

The general objective of this study was to investigate how Digital Information and Communication Technologies (DICTs) have been used in the adaptation of mathematical activities for EJA – High School students, analyzing theoretical productions and documents related to the theme. In an articulated way, it was also sought to relate the DICTs with mathematical contents of EJA, to propose contextualized and meaningful activities, to evaluate their pedagogical potentials and limitations and to contribute to an educational product aimed at teachers.

The bibliographic and documentary research, organized into analytical categories, allowed the systematization of theoretical and didactic evidence that demonstrates the role of DICTs in the promotion of more meaningful, inclusive and contextualized pedagogical practices. The analysis of the proposed activities indicates that, when articulated with critical and intentionally planned pedagogical proposals, the DICTs contribute to broaden the visualization of abstract mathematical concepts, favor student engagement and protagonism, and bring Mathematics closer to the daily experiences of EJA students. Resources such as simulators, applications, gamification platforms and mobile devices proved to be relevant to resignify the teaching of Mathematics, especially when dialoguing with school trajectories marked by interruptions and conceptual difficulties, in line with the references of Freire, Vygotsky and D'Ambrosio.

It was also evidenced that the use of DICTs in EJA still faces significant structural and training challenges, such as the precariousness of the technological infrastructure, inequalities in digital access and the insufficiency of specific teacher training for the pedagogical use of

these technologies. These limitations confirm the reflections of Kenski and Fiuza, when they emphasize that educational technology is not neutral and requires adequate conditions of implementation and pedagogical intentionality.

The proposed activities seek to contribute to the expansion of the repertoire of didactic practices aimed at EJA, by presenting concrete examples of the use of DICTs in the teaching of Mathematics, without, however, intending to exhaust the possibilities of research on the subject. In this sense, the research dialogues with the literature by defending a critical, mediated and contextualized approach to digital technologies, offering theoretical-pedagogical subsidies for teachers and researchers interested in the construction of more inclusive, situated and socially significant educational practices.

Regarding the limitations of the research, the exclusively bibliographic and documentary nature of the study is highlighted, which, although adequate to the proposed objective, does not allow for direct observation of the implementation of DICTs in real school contexts. Thus, the results reflect trends and theoretical and didactic evidence present in the literature, not contemplating the empirical analysis of teaching practices and students' learning.

In view of this, it is suggested that future research move towards empirical investigations, such as case studies, action research or pedagogical interventions in EJA contexts, in order to analyze the concrete application of DICTs in the teaching of Mathematics. It is also recommended the development of studies aimed at teacher training for the critical use of technologies, the evaluation of the impact of these practices on student learning and the analysis of public policies for digital inclusion in EJA, expanding and deepening the discussions initiated in this research.

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TUTORING MODELS IN ARTIFICIAL INTELLIGENCE AND KNOWLEDGE SKILLS IN THE CONTEXT OF INDUSTRY 5.0

MODELOS DE TUTORIA EM INTELIGÊNCIA ARTIFICIAL E HABILIDADES DE CONHECIMENTOS NO CONTEXTO DA INDÚSTRIA 5.0

MODELOS DE TUTORÍA EN INTELIGENCIA ARTIFICIAL Y HABILIDADES DE CONOCIMIENTO EN EL CONTEXTO DE LA INDUSTRIA 5.0



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ABSTRACT

The expansion of generative artificial intelligence has increased the presence of digital tutoring systems in educational and corporate environments, enhancing the capacity for personalization, scalability, and availability of learning support. At the same time, Industry 5.0 repositions human beings at the center of technological transformation, reinforcing the relevance of knowledge skills for continuous learning, adaptability, and value creation. This article analyzes how artificial intelligence tutoring models relate to the development of knowledge skills in the context of Industry 5.0. The study adopts a theoretical conceptual approach, developed through an integrative literature review based on the authors' doctoral qualification texts and the project's authorized sources. The findings indicate that human, artificial, and hybrid tutoring models produce distinct effects on autonomy, motivation, engagement, self-regulated learning, and the development of cognitive, digital, and adaptive competencies. It concludes that AI-based tutoring can serve as a support infrastructure for the development of knowledge skills, provided it operates within a human-centered logic, articulated with pedagogical principles, human curation, knowledge-creation, and circulation processes.

Keywords: Artificial Intelligence (AI). Tutoring Models. Knowledge Skills. Industry 5.0. Generative AI.

RESUMO

A expansão da inteligência artificial generativa ampliou a presença de sistemas de tutoria digital em ambientes educacionais e corporativos, elevando a capacidade de

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personalização, a escalabilidade e a disponibilidade do suporte à aprendizagem. Em paralelo, a Indústria 5.0 reposiciona o ser humano no centro da transformação tecnológica, reforçando a relevância das habilidades de conhecimento para a aprendizagem contínua, a adaptabilidade e a criação de valor. Este artigo analisa como modelos de tutoria em inteligência artificial se relacionam ao desenvolvimento de habilidades de conhecimento no contexto da Indústria 5.0. O estudo adota uma abordagem teórico-conceitual, desenvolvida por meio de revisão integrativa da literatura, com base nas produções de qualificação dos autores e nas fontes autorizadas do projeto. Os achados indicam que modelos de tutoria humana, artificial e híbrida produzem efeitos distintos sobre a autonomia, a motivação, o engajamento, a aprendizagem autorregulada e o desenvolvimento de competências cognitivas, digitais e adaptativas. Conclui-se que a tutoria baseada em IA pode atuar como infraestrutura de apoio ao desenvolvimento de habilidades de conhecimento, desde que operada com lógica human-centered, articulada a princípios pedagógicos, à curadoria humana e a processos de criação e de circulação do conhecimento.

Palavras-chave: Inteligência Artificial (IA). Modelos de Tutoria. Habilidades de Conhecimentos. Indústria 5.0. IA Generativa.

RESUMEN

La expansión de la inteligencia artificial generativa ha ampliado la presencia de sistemas de tutoría digital en entornos educativos y corporativos, elevando la capacidad de personalización, la escalabilidad y la disponibilidad del apoyo al aprendizaje. Al mismo tiempo, la Industria 5.0 reposiciona al ser humano en el centro de la transformación tecnológica, reforzando la relevancia de las habilidades de conocimiento para el aprendizaje continuo, la adaptabilidad y la creación de valor. Este artículo analiza cómo los modelos de tutoría basados en inteligencia artificial se relacionan con el desarrollo de habilidades de conocimiento en el contexto de la Industria 5.0. El estudio adopta un enfoque teórico-conceptual, desarrollado mediante una revisión integradora de la literatura, con base en las producciones de calificación de los autores y en las fuentes autorizadas del proyecto. Los hallazgos indican que los modelos de tutoría humana, artificial e híbrida producen efectos distintos sobre la autonomía, la motivación, el compromiso, el aprendizaje autorregulado y el desarrollo de competencias cognitivas, digitales y adaptativas. Se concluye que la tutoría basada en IA puede actuar como infraestructura de apoyo al desarrollo de habilidades de conocimiento, siempre que opere bajo una lógica human-centered, articulada con principios pedagógicos, la curaduría humana, los procesos de creación y circulación del conocimiento.

Palabras clave: Inteligencia Artificial (IA). Modelos de Tutoría. Habilidades de Conocimiento. Industria 5.0. IA Generativa.

1 INTRODUCTION

The incorporation of Artificial Intelligence (AI) in educational environments has ceased to occupy a peripheral position and has become part of broader strategies for learning mediation, especially with the dissemination of generative models and conversational interfaces. In parallel, Industry 5.0 has consolidated an agenda that combines technological transformation, sustainability, resilience, and human centricity, shifting the debate from the mere use of technology to the ability to develop skills and transform knowledge into organizational value (European Commission, 2025; Ghobakhloo et al., 2022; Xu et al., 2021).

In the educational field, this movement manifests in the expansion of digital tutors, academic assistants, and systems that answer questions, organize content, offer feedback, and support self-regulated learning. Recent studies indicate that AI-based tutors can improve the learning experience when they combine technical responsiveness with consistent pedagogical foundations, especially in higher education and distance education contexts (Baillifard et al., 2025; Ding et al., 2023; Reicher et al., 2025).

The effectiveness of this type of solution, however, does not depend only on technical availability. The literature shows that perceived utility, ease of use, enabling conditions, motivation, autonomy, and quality of mediation continue to be decisive factors for engagement and sustained use of technology-mediated educational systems (Davis, 1989; Ryan & Deci, 2000; Tbaishat et al., 2026; Venkatesh & Bala, 2008).

This debate gains density when connected to Industry 5.0-driven environments, as the central issue is no longer just the adoption of AI but its ability to support the development of knowledge skills, understood as capacities to learn, interpret, combine, apply, and share knowledge in complex, digital, and intensively changing contexts (Alavi & Leidner, 2001; Leon, 2023; Nonaka, 1994; World Economic Forum, 2025). In this context, cognitive, digital, relational, and adaptive competencies become critical assets for the creation and circulation of organizational knowledge (Nonaka & Takeuchi, 1995; Rikala et al., 2024).

The theoretical gap lies precisely in the intersection between these two agendas. Literature has advanced the analysis of intelligent tutors, AI-mediated learning, technological acceptance, and motivation. It also advanced the discussion on competencies, skills gaps, knowledge management, and Industry 5.0. Even so, an integrative reading that explains how AI tutoring models can contribute to the formation and mobilization of knowledge skills required in environments of accelerated digital transformation and continuous learning remains less developed (Anshari & Hamdan, 2022; Cerchione et al., 2024; Shen et al., 2025).

Therefore, this article aims to analyze, from a theoretical-conceptual perspective, how different models of tutoring (human, artificial, and hybrid) relate to the development of knowledge skills in the context of Industry 5.0. The relevance of the study is both theoretical, as it integrates two fields that usually run in parallel, and practical, as it offers a useful basis for designing more effective tutoring solutions in educational and organizational contexts.

2 THEORETICAL FOUNDATIONS

2.1 TUTORING MODELS IN ARTIFICIAL INTELLIGENCE

Tutoring, in its classic formulation, serves a mediating function among the student, the content, and the learning process. In digital environments, this function has expanded to include automated support, recommendation, feedback, and follow-up mechanisms (Massuga et al., 2021; Peel et al., 2023). Currently, three main tutoring arrangements can be found in educational and corporate settings: human tutoring, artificial tutoring, and hybrid tutoring.

In human tutoring, a pedagogical representative offers support through welcome, guidance, feedback, and relationship building. This model tends to offer greater interpretive density, greater contextual sensitivity, and a stronger ability to address the subjective dimensions of learning, such as insecurity, belonging, and motivation. On the other hand, it faces limitations in scale, availability, and standardization (Massuga et al., 2021; Peel et al., 2023).

In artificial tutoring, support is provided by AI-based systems, often supported by natural language processing, generative models, and knowledge retrieval mechanisms. These systems increase availability, reduce response time, personalize interactions, and expand the capacity for continuous support, especially for operational questions, conceptual reinforcement, and study organization (Ding et al., 2023; Hobert & Berens, 2024; Lee, 2025; Reicher et al., 2025).

And, hybrid tutoring combines the advantages of both models, in which AI tends to operate as the first layer of support, absorbing recurring demands and structuring initial guidance, while the human tutor remains responsible for more complex mediations, welcoming, conceptual deepening, and pedagogical judgment. Literature has indicated that this format tends to be more robust in contexts in which speed and scale need to coexist with relational quality and pedagogical consistency (Alfirević et al., 2025; Seo et al., 2021).

In addition to the delivery format, AI tutoring models vary in their interaction architecture, with some systems limited to on-demand responses and others incorporating proactive elements such as reminders, study recommendations, encouragement of engagement, and

support for self-regulation. This point is relevant because it shifts tutoring from a merely reactive function to a broader formative function (He, 2025; L. Liu et al., 2024; Yin et al., 2026).

Still, the limits are clear to artificial tutors, which can increase the efficiency of support, but they do not, by themselves, guarantee cognitive depth, pedagogical quality, or criticality - without curation, instructional design, and validation mechanisms, there is a risk of superficiality, inaccurate answers, and excessive dependence of the student on the system (Đerić et al., 2025; Kasneci et al., 2023; Tharapos et al., 2025).

2.1.1 The artificial tutor: definition, architecture, and application contexts

An artificial tutor based on generative AI is a computer system that interacts with users in natural language, offering personalized support, answering questions, providing feedback, and automatically guiding learning processes. Unlike classical tutoring systems based on fixed rules, tutors in generative AI, especially those supported by Large Language Models (LLMs), operate through probabilistic models trained on large volumes of text, which allows them to generate contextually relevant responses, adapt to the user's interaction style, and handle ambiguity (Kasneci et al., 2023; Lee, 2025; Reicher et al., 2025).

The most common architecture includes three main layers: the conversational interface, which enables natural-language interaction; the processing layer, which combines generative models with Retrieval-Augmented Generation (RAG) techniques; and the curated knowledge base, which guides the system's responses with institutionally validated content. This framework allows the artificial tutor to offer immediate responses, personalize study paths, monitor the user's progress, and, in more advanced settings, identify learning gaps and suggest pedagogical interventions (Ding et al., 2023; Lee, 2025; Yin et al., 2026).

In the academic context, artificial tutors can be used to clarify concepts, support the resolution of exercises, guide reviews, stimulate self-regulation of learning, and offer adaptive simulations. Its application is especially relevant in disciplines with high demand for support, in distance education environments, and in contexts where the ratio of students to available human tutors is unfavorable (Baillifard et al., 2025; Hobert & Berens, 2024).

In the business context, AI mentoring can support upskilling and reskilling programs, technical training trails, onboarding new employees, professional certification support, and the dissemination of organizational knowledge. In this scenario, the tutor acts as a facilitator of access to corporate knowledge, reducing the response time to operational questions and expanding the scalability of development programs (Anshari & Hamdan, 2022; Leon, 2023; World Economic Forum, 2025).

However, the effectiveness of the artificial tutor depends on structural conditions. The first is the curation of the knowledge base, which must be accurate, up-to-date, and expert-validated. The second is clarity about the scope of the system's actions, avoiding unrealistic expectations that it can replace complex human mediation. The third is training users to interact productively with the tutor, formulating clear questions, validating answers, and using the system as support rather than a substitute for critical thinking. Without these conditions, the tutor can expand access, but compromise the quality of learning (Đerić et al., 2025; Kasneci et al., 2023; Tharapos et al., 2025).

2.2 TECHNOLOGICAL ACCEPTANCE, MOTIVATION, AND USE OF AI TUTORING

Understanding the effective use of AI tutoring systems requires more than a mere functional description of the technology. It is necessary to understand how users perceive, accept, and incorporate these systems into their learning routines. In this field, the Technology Acceptance Model (TAM), proposed by Davis (1989) continues to be one of the most influential frameworks for explaining technology adoption.

According to the TAM, the intention to use is strongly influenced by two core beliefs: perceived utility and perceived ease of use. In AI-mediated educational contexts, these two variables remain particularly relevant, as the perception of practical value and the absence of technical barriers directly affect engagement with digital tutors and learning platforms (Davis, 1989; Davis et al., 1989; Ngo et al., 2025). The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) expands this analysis by incorporating contextual and social factors, such as performance and effort expectations, social influence, and enabling conditions. This expansion is important because the decision to use an AI tutor depends not only on the interface but also on infrastructure, institutional support, the culture of use, and prior experience with digital tools (Acikgul & Sad, 2026).

In the case of the artificial tutorial, recent research shows that students strongly value attributes such as speed, continuous availability, accessible language, consistency of answers, and concrete usefulness for tasks and assessments - when these elements are present, technology tends to be perceived as an ally, when they are not, it is seen as operational noise or a low-confidence solution (Al-Abri, 2025; Ding et al., 2023; Hobert & Berens, 2024).

But the adoption of artificial tutors cannot be explained by instrumental factors alone. Self-Determination Theory (SDT) adds a decisive layer to the debate by showing that sustained engagement depends on the satisfaction of three basic psychological needs: autonomy, competence, and relationship (Niemic & Ryan, 2009; Ryan & Deci, 2000).

In technology-mediated environments, this means that a tutoring solution tends to be more effective when, in addition to being functional, it reinforces the student's sense of autonomy, expands their perception of competence, and sustains some level of bonding or welcoming. This point helps explain why some technically efficient systems don't necessarily produce deep engagement or lasting learning (Chiu, 2024; Li et al., 2024; Puderbach et al., 2025).

Recent research has made progress by combining technological acceptance with motivation, and these integrated models suggest that understanding the adoption of generative AI in education is clearer when cognitive, contextual, and motivational factors are considered together. In educational terms, users do not engage with a tutor just because it is available, but because they see its value, feel capable of using it, find it supportive, and believe that the technology helps them to progress and become more autonomous (Tbaishat et al., 2026).

2.3 KNOWLEDGE SKILLS AND KNOWLEDGE CREATION

In the context of Industry 5.0, the discussion of competencies needs to go beyond the traditional technical repertoire, as the contemporary agenda values skills that integrate technology, cognition, adaptation, judgment, collaboration, and knowledge creation. Therefore, the expression knowledge skills is useful in this article, as it refers not only to the mastery of information, but to the ability to transform knowledge into action, learning, and value (European Commission, 2025; Sheikh et al., 2025; World Economic Forum, 2025).

Accelerated transformation scenarios and skill gaps are no longer merely operational problems; they are beginning to pose a direct risk to competitiveness, innovation, and organizational learning capacity. Therefore, cognitive, digital, adaptive, and relational skills should be treated as strategic assets and as inputs for broader processes of knowledge creation and circulation (Leon, 2023; Rikala et al., 2024).

This reading dialogues directly with Organizational Knowledge Creation (OKC), developed by Nonaka and collaborators. The SECI model explains that organizational knowledge emerges through the continuous conversion between tacit and explicit knowledge, in four movements: Socialization, Externalization, Combination, and Internalization, with the initials of these words forming the acronym. The central point here is simple but decisive: knowledge is not only stored but also created, shared, structured, and reapplied in dynamic cycles (Nonaka, 1994; Nonaka et al., 2000; Nonaka & Takeuchi, 1995).

From this perspective, knowledge skills can be understood as individual and collective capacities that feed these cycles. The ability to formulate questions, interpret answers, connect

concepts, explain experiences, learn from feedback, recombine content, and apply knowledge in new contexts is not peripheral - it is part of the very process of creating organizational knowledge (Alavi & Leidner, 2001; Cerchione et al., 2024; Gold et al., 2001).

The perspective of Knowledge Management Processes (KMP) reinforces this reading. Processes such as the creation, storage, transfer, and application of knowledge depend on competencies distributed among individuals, teams, and systems. When these competencies are fragile, misaligned, or poorly mobilized, the flow of knowledge loses quality. As a consequence, the skills gap can be interpreted not only as individual insufficiency but also as a symptom of limitations in the very mechanisms of knowledge conversion and use (Alavi & Leidner, 2001; Anshari & Hamdan, 2022; C. Liu, 2024).

This argument is especially relevant to Industry 5.0, as this paradigm expands the need for continuous learning and collaboration between humans and intelligent systems. In this environment, value arises not solely from automation but from the integration of technology with human judgment, creativity, contextual interpretation, and adaptive learning (European Commission, 2025; Sheikh et al., 2025; Xu et al., 2021).

2.4 AI TUTORING AND KNOWLEDGE SKILLS IN INDUSTRY 5.0

The link between AI tutoring and knowledge skills becomes clearer when one abandons a merely instrumental view of technology. An AI-based tutor should not be seen as just an autoresponder mechanism; in a more mature design, it operates as a layer of support for learning, reflective practice, study organization, access to knowledge, and the internalization of useful repertoires for decision-making and problem-solving (He, 2025; Lee, 2025; Reicher et al., 2025).

When well-designed, AI tutoring models can strengthen skills such as learning autonomy, question formulation, the ability to search for and validate information, conceptual articulation, adaptation to feedback, content synthesis, and practical use of knowledge. These capabilities speak directly to the demands of Industry 5.0, especially in environments where continuous updating, critical interpretation, and workflow learning become essential (Chiu, 2024; Leon, 2023; World Economic Forum, 2025).

At the same time, the literature suggests that the gain is not in replacing human mediation but in repositioning it. Instead of focusing the human tutor on repetitive, operational responses, AI can absorb some of that volume, freeing up space for higher-density interactions, such as mentoring, interpretation, contextualization, and formative follow-up. This redistribution of roles

is consistent with the human-centered logic of Industry 5.0, in which technology should expand, not reduce, human potential (Alfirević et al., 2025; Seo et al., 2021; Shen et al., 2025).

This arrangement also makes sense from a knowledge management perspective. If artificial tutoring can support the externalization of doubts, the combination of contents, the internalization of concepts, and the circulation of useful answers, it can operate as a complementary mechanism to SECI cycles. This does not mean attributing to technology the role of autonomous creator of organizational knowledge, but recognizing it as an infrastructure that supports mediation, sharing, and interaction-based learning (Cerchione et al., 2024; C. Liu, 2024; Nonaka et al., 2000).

In summary, AI tutoring can contribute to the development of knowledge skills when it meets five central conditions: practical relevance for the user, ease of use, integration with motivational principles, pedagogical curation, and articulation with broader processes of knowledge creation and application. Without this, technology may even achieve initial adoption, but it is unlikely to produce a consistent formative impact.

3 METHODOLOGY

This article adopts a qualitative, theoretical-conceptual approach, developed through an integrative literature review. The analytical construction starts from the intersection between two main axes: the literature on AI tutoring in higher education, with an emphasis on technological acceptance, motivation, and AI-mediated learning, and the literature on skills, skill gaps, knowledge creation, and Industry 5.0.

The analysis was conducted through a cross-thematic synthesis. The sources were organized into four analytical blocks: tutoring models; technological acceptance and motivation; knowledge and knowledge-creation skills; and Industry 5.0. From this, we identified convergences, tensions, and conceptual interfaces that could sustain an integrative interpretation of the phenomenon under investigation.

The choice of a theoretical-conceptual article is justified because the objective of this stage is not to test a specific model empirically, but to consolidate an analytical basis of two strands that, until then, have been in parallel. Rather than fragmenting the debate, the article builds an interpretive bridge between intelligent mentoring and the development of knowledge skills, focusing on analytical utility and managerial applicability.

4 RESULTS AND DISCUSSION

4.1 CONTRIBUTIONS OF AI TUTORING MODELS TO THE DEVELOPMENT OF KNOWLEDGE SKILLS

The main contribution of AI tutoring models lies in their ability to reduce friction in accessing support and to increase the availability of mediation. In practical terms, this means that the student or user can resort to the system when in doubt, at their own pace and with greater autonomy. This point is decisive because contemporary learning relies less and less on formal windows of instruction and more and more on timely, contextual, and responsive support (Ding et al., 2023; Hobert & Berens, 2024; Reicher et al., 2025).

This type of support favors the development of skills and knowledge on at least four fronts. The first is autonomy, as well-designed tutoring systems help the user to advance without relying exclusively on immediate human interventions. The second is competence: quick feedback and accessible explanations can strengthen the perception of progress. The third is self-regulated learning, as the tutor's availability encourages planning, monitoring, and reviewing one's own study path. The fourth is cognitive articulation, since the user needs to formulate questions, refine commands, interpret answers, and validate information (Chiu, 2024; He, 2025; Ryan & Deci, 2000).

These gains are in direct adherence to the logic of Industry 5.0. Recent literature shows that contemporary work and learning environments require professionals who can engage in continuous learning, operate in hybrid ecosystems, navigate ambiguity, integrate information and judgment, and develop adaptive repertoires. From this perspective, an AI tutor is not only an academic support tool, but it can also be a mechanism for continuous training of competencies associated with the strategic use of knowledge (Leon, 2023; Sheikh et al., 2025; World Economic Forum, 2025).

4.2 COMPARATIVE SYNTHESIS: MODELS OF TUTORING, MEDIATION AND SKILLS DEVELOPMENT

The theoretical analysis developed in the previous sections allowed us to articulate, in a structured way, the relationships between AI tutoring models, pedagogical mediation mechanisms, developed knowledge skills, and adherence to the principles of Industry 5.0. This synthesis was not limited to describing isolated characteristics of each model, but sought to highlight how the use of AIs, specifically in the different tutoring models, can influence, in a different way, the development of critical skills for continuous learning, adaptability, and the creation of knowledge in digital and organizational environments.

Table 1 summarizes these relationships comparatively, showing that the choice of the tutoring model is not neutral: it directly affects which knowledge skills are favored, which mediation processes are activated, and which logic of human centrality or technological scalability prevails; the latter in adherence to the principles of Industry 5.0.

Table 1

Relationship between AI tutoring models, mediation mechanisms, and knowledge skills development

Tutoring Models	Mediation mechanisms	Favored knowledge skills	Adherence to Industry 5.0
Human tutoring	welcoming, bonding, interpretation, judgment, feedback	relational contextual pedagogical qualitative critical collaboration, sensitivity, competence	thinking, contextual relational human learning, mediation centrality, situated qualitative
Artificial tutoring	continuous availability, fast response, algorithmic personalization, scalable access, and immediate feedback	learning autonomy, digital competence, question formulation, information self-regulated validation, learning	scalability, on-demand learning, digital workflow support
Hybrid tutoring	combination of scale (AI) and depth (human), automated screening, deepening, pedagogical curation	autonomy, competence, critical thinking, digital adaptability, human-AI collaboration	human-centered technology, continuous learning, collaborative knowledge creation

Source: Prepared by the authors.

Through this relationship, it was possible to identify that the hybrid model presented a greater balance between scalability and pedagogical depth. When comparing these three models, human tutoring favors relational and contextual skills but faces structural limitations in availability; artificial tutoring expands access and speed but can compromise criticality and interpretation; and the hybrid model articulates the two mediation registers in a complementary way. In this configuration, AI takes on operational and first-layer support functions, while the human tutor remains responsible for conceptual deepening, pedagogical validation, and welcoming (Alfirević et al., 2025; Seo et al., 2021).

This division of labor is not only functional. It expresses a design decision about what should be automated and what should remain under human responsibility. When well implemented, this separation allows the human tutor to focus his energy on interactions of greater formative density, freeing up time previously consumed by repetitive responses, operational clarifications, and low-complexity support. At the same time, the AI system becomes more effective by being delimited in its scope, avoiding functional overload or unrealistic

expectations regarding its ability to replace complex pedagogical mediation (Hobert & Berens, 2024; Massuga et al., 2021; Shen et al., 2025).

From a knowledge management perspective, it is possible to integrate artificial tutoring into the processes of knowledge creation, sharing, and application. From the perspective of the SECI model, proposed by Nonaka and colleagues, artificial tutoring can especially support three movements in the knowledge conversion cycle: externalization, by encouraging users to formulate questions and articulate doubts explicitly; the combination, by organizing, structuring, and connecting different contents in an accessible and personalized way; and internalization, by facilitating the practical application of concepts through immediate feedback and adaptive exercises (Nonaka, 1994; Nonaka et al., 2000; Nonaka & Takeuchi, 1995).

This positioning does not attribute to AI the role of autonomous creator of organizational knowledge, but recognizes it as an infrastructure to support the mediation, circulation, and application of knowledge in learning contexts. When integrated into broader KMP processes, artificial tutoring can increase the efficiency of knowledge transfer, reduce barriers to access, and strengthen learning cycles in educational organizations and institutions (Alavi & Leidner, 2001; Cerchione et al., 2024; C. Liu, 2024).

However, the effectiveness of this arrangement depends on five structural conditions that must be met simultaneously. The first is the curation of the knowledge base, which ensures the accuracy, updating, and validation of the information accessed by the artificial tutor. Without curation, the system can expand access, but generate inaccurate, outdated, or decontextualized answers, compromising trust and the quality of learning (Kasneci et al., 2023; Tharapos et al., 2025). The second condition is the clarity of scope, which delimits what the artificial tutor can and should do. AI systems are not a substitute for pedagogical judgment, contextual sensitivity, or relational acceptance. When these limits are not made explicit, unrealistic expectations arise, leading to user frustration and distrust of technology (Al-Abri, 2025; Đerić et al., 2025). The third condition is the user's training, which requires developing skills to interact productively with the artificial tutor. This includes formulating clear questions, interpreting answers, validating information, identifying biases or inaccuracies, and using the system to support critical thinking rather than substituting for reflection. Without this training, the use of AI can be superficial, passive, or dependent (Chiu, 2024; He, 2025). The fourth condition is integration with motivational principles, especially those derived from SDT. Artificial tutors who reinforce student autonomy, offer feedback that broadens the perception of competence, and sustain some level of bonding or nurturing tend to promote greater engagement and sustained use. On the other hand, systems that only deliver answers, without formative guidance, can be

perceived as cold, instrumental, or disconnected from the real learning process (Li et al., 2024; Ryan & Deci, 2000; Tbaishat et al., 2026). The fifth condition is institutional governance, which defines responsibilities, validation criteria, feedback mechanisms, processes for updating the knowledge base, and forms of articulation between human and artificial tutoring. Without clear governance, the implementation of AI tutors tends to be fragmented, unsustainable, and disconnected from broader formative goals (European Commission, 2025; Shen et al., 2025).

When these five conditions are met, the hybrid tutoring model becomes particularly aligned with the principles of Industry 5.0. This paradigm values not automation for automation's sake, but the ability to combine technology with human centricity, continuous learning, sustainability, and organizational resilience. In this framework, artificial or hybrid tutoring is no longer just an operational support tool but becomes part of the infrastructure for developing knowledge skills, especially those associated with adaptability, critical thinking, digital competence, and the ability to learn autonomously in fast-changing environments (European Commission, 2025; Ghobakhloo et al., 2022; Xu et al., 2021).

Finally, by explaining the relationships between the tutoring model, mediation mechanisms, developed skills, and adherence to Industry 5.0, this research presented criteria for the conscious choice of tutoring configurations, evaluation of educational technologies, and the creation of training trails that combine human development and technological support in a coherent and sustainable way (Leon, 2023; Rikala et al., 2024; World Economic Forum, 2025).

4.3 LIMITS, RISKS AND NECESSARY MEDIATIONS

It would be simplistic to treat AI tutoring as a sufficient solution on its own. The literature shows that the presence of generative systems does not eliminate problems of quality, depth, criticality, or cognitive dependence. In some cases, the fluidity of the response creates a false perception of accuracy; in others, the ease of support encourages passive use, without self-elaboration or without adequate validation of the content (Đerić et al., 2025; Kasneci et al., 2023; Tharapos et al., 2025).

This risk becomes more pronounced when the goal is not only to transmit information but also to develop knowledge skills. Knowing how to access an answer is not the same as knowing how to build knowledge. Real competence development requires interpretation, confrontation of perspectives, reflection, application, and the ability to transfer learning to new contexts. Without these elements, digital tutoring can improve operational efficiency but yield limited formative impact.

Therefore, human mediation remains central. The human tutor, the teacher, the instructional designer, or the manager of the learning process remains essential for defining criteria, validating content, guiding criticality, and sustaining the pedagogical bond. The point, therefore, is not to choose between humans and AI, but to design arrangements in which technology takes over what it does best – speed, scale, availability, and operational support – while humans focus their energy on what requires judgment, context, sensitivity, and depth (Alfirević et al., 2025; Massuga et al., 2021; Seo et al., 2021).

5 CONCLUSION

This article looked at how different mentoring models – human, artificial, and hybrid – relate to the development of knowledge skills in the context of Industry 5.0. The theoretical and conceptual synthesis allowed us to sustain that the AI-mediated tutorial can contribute in a relevant way to autonomy, self-regulated learning, access to knowledge, digital competence, and adaptability, as long as its adoption is articulated with pedagogical, motivational, and organizational criteria, and not only to gains in technological efficiency (Chiu, 2024; Davis, 1989; European Commission, 2025).

The central argument is straightforward: in Industry 5.0, the value of AI in learning environments does not lie only in the ability to respond quickly; it lies in its ability to strengthen human learning, expand the creation and circulation of knowledge, and support the development of competencies that remain critical precisely because the environment has become more technological, not less human. When designed with this logic, AI tutoring is no longer merely an operational accessory but functions as a development infrastructure.

The findings also indicated that the hybrid model tends to offer the best balance between scale, availability, depth, and welcoming. This is not a methodological detail; It's a design decision. And, as is often the case with projects that seem to be resolved too soon, the problem is rarely in the technology alone – it lies in the adopted mediation model.

The article opens the way for empirical studies on the different types of tutoring in Higher Education Institutions (HEIs), corporate environments, and executive training programs. The investigation of metrics that more objectively relate mentoring models to the satisfaction of psychological needs, the development of skills and knowledge, and their effects on academic and organizational performance is also promising.

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INVENTORY PLANNING AND CONTROL IN ORGANIZATIONS

PLANEJAMENTO E CONTROLE DE ESTOQUE NAS ORGANIZAÇÕES

PLANIFICACIÓN Y CONTROL DE INVENTARIOS EN LAS ORGANIZACIONES



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ABSTRACT

The contemporary organizational context is characterized by high levels of competitiveness, dynamic markets, and increasing complexity in logistical operations, which demand greater efficiency in the management of available resources. In this scenario, inventory planning and control play a fundamental role, as they directly impact operational continuity, cost reduction, and customer service levels. In light of this, the general objective of this study is to highlight the strategic relevance of inventory planning and control within organizations, as well as the main methods and techniques employed and their impacts on organizational performance. To achieve these objectives, a qualitative approach was adopted, grounded in bibliographic research. The study was developed based on the analysis of well-established materials in the literature, such as books and scientific articles by recognized authors in the field of logistics and inventory management, enabling the construction of a consistent theoretical foundation on the topic. The findings indicate that supply management professionals must go beyond the operational mastery of control tools and techniques, developing a strategic perspective that enables the integration of inventory data with managerial decision-making and organizational objectives. Such capability constitutes a significant competitive advantage in the current context, marked by the complexity of supply chains and increasing demands for efficiency and agility in operations.

Keywords: Inventory Planning. Inventory Control. Supply Management. Organizational Performance.

RESUMO

O contexto contemporâneo das organizações é marcado por elevados níveis de competitividade, dinamismo dos mercados e crescente complexidade nas operações logísticas, o que exige maior eficiência na gestão dos recursos disponíveis. Nesse cenário, o planejamento e o controle de estoque assumem papel fundamental, uma vez que impactam diretamente a continuidade operacional, a redução de custos e o nível de serviço ao cliente. Diante disso, o objetivo geral desta pesquisa é destacar a relevância estratégica do planejamento e do controle de estoque nas organizações, bem como dos principais métodos e técnicas utilizados e de seus impactos no desempenho organizacional. Para o

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alcançe desses objetivos, adotou-se uma abordagem qualitativa, fundamentada em pesquisa bibliográfica. O estudo foi desenvolvido a partir da análise de materiais já consolidados na literatura, como livros e artigos científicos de autores reconhecidos na área de logística e gestão de estoques, permitindo a construção de uma base teórica consistente sobre o tema. Como resultado, a pesquisa evidenciou que o profissional de Gestão de Suprimentos precisa ir além do domínio operacional de ferramentas e técnicas de controle, sendo necessário desenvolver uma visão estratégica que possibilite integrar as informações de estoque às decisões gerenciais e aos objetivos organizacionais. Essa capacidade configura-se como um diferencial competitivo relevante no contexto atual, caracterizado pela complexidade das cadeias logísticas e pela crescente exigência por eficiência e agilidade nas operações.

Palavras-chave: Planejamento de Estoque. Controle de Estoque. Gestão de Suprimentos. Desempenho Organizacional.

RESUMEN

El contexto contemporáneo de las organizaciones se caracteriza por altos niveles de competitividad, dinamismo de los mercados y creciente complejidad en las operaciones logísticas, lo que exige una mayor eficiencia en la gestión de los recursos disponibles. En este escenario, la planificación y el control de inventarios asumen un papel fundamental, ya que impactan directamente en la continuidad operativa, la reducción de costos y el nivel de servicio al cliente. Por lo tanto, el objetivo general de esta investigación es destacar la relevancia estratégica de la planificación y el control de inventarios en las organizaciones, así como los principales métodos y técnicas utilizados y sus impactos en el desempeño organizacional. Para alcanzar estos objetivos, se adoptó un enfoque cualitativo, fundamentado en una investigación bibliográfica. El estudio se desarrolló a partir del análisis de materiales ya consolidados en la literatura, como libros y artículos científicos de autores reconocidos en el área de logística y gestión de inventarios, permitiendo la construcción de una base teórica consistente sobre el tema. Como resultado, la investigación evidenció que el profesional de Gestión de Suministros necesita ir más allá del dominio operativo de herramientas y técnicas de control, siendo necesario desarrollar una visión estratégica que permita integrar la información de inventarios con las decisiones gerenciales y los objetivos organizacionales. Esta capacidad se configura como una ventaja competitiva relevante en el contexto actual, caracterizado por la complejidad de las cadenas logísticas y la creciente exigencia de eficiencia y agilidad en las operaciones.

Palabras clave: Planificación de Inventarios. Control de Inventarios. Gestión de Suministros. Desempeño Organizacional.

1 INTRODUCTION

Supply chain complexity is increasing, demand is fluctuating, and there is intense pressure to reduce operating costs. Inventory planning and control become invaluable strategic functions for organizations of any size and in any domain in this situation.

One of the biggest challenges is the efficient management of inventory among those who are in the purchasing and supply area. Maintaining adequate inventory levels refers to two competing risks: excess (cost of maintaining inventory, leading to storage, obsolescence, and capital immobilization); and scarcity (supply disruptions, lost sales, loss of customers, and dissatisfaction).

Achieving this balance is complicated and depends on the use of strategies, methods, tools, and indicators that will be available to enable accurate decision-making. Faced with this problem, several methods have been developed in recent decades to allow the direct management of inventory sizing to be applied more precisely. Methods such as reorder point, safety stock, ABC analysis, and economic order quantity (EOQ) model are now established benchmarks in materials management.

In addition to the technical level, inventory management has a strategic layer that links the supply part to the organization's overall strategy. Choices about inventory levels affect cash flow, production capacity, and end-user service. Thus, any professional must be able to understand the theoretical and practical basis of inventory planning and control.

The general objective of this research is to highlight the strategic relevance of inventory planning and control in organizations, as well as the main methods and techniques used and their impacts on organizational performance. The specific objectives are as follows: To examine the strategic importance of inventory planning for operational efficiency and decision-making in organizations; Describe and analyze the main methods and techniques of inventory control adopted by organizations; Evaluate the impacts of inventory management on organizational performance, considering indicators such as costs, service level, and competitiveness.

In order to achieve these objectives, a methodology characterized by a qualitative approach was developed and the research procedure used was the bibliographic research, developed based on materials already published, such as books and scientific articles by relevant authors in the area of logistics and inventory management.

This article is structured in four sections. Initially, the introduction presents the theme and explains the objectives of the research. Next, the methodology describes the approach adopted and the procedures used for the development of the study. In the third section, the theoretical foundation is organized into three axes: the strategic importance of inventory planning, the

methods and techniques of inventory control, and the impacts of inventory management on organizational performance. Finally, in the final considerations, the main results are resumed, evidencing the achievement of the proposed objectives, in addition to indicating possibilities for future research.

2 METHODOLOGY

The approach adopted in this work is qualitative, as it seeks to understand the importance of inventory planning and control from the analysis of concepts and theoretical contributions. This type of approach allows for a more in-depth interpretation of organizational phenomena, without the use of numerical data. According to Gil (2020, p.92), "qualitative research aims to understand phenomena from the perspective of the participants and the interpretation of the researcher".

As for the research procedure, bibliographic research was used, developed based on materials already published, such as books and scientific articles by relevant authors in the area of logistics and inventory management. This procedure allows us to gather different theoretical views on the subject. According to Lakatos and Marconi (2021, p. 166), "bibliographic research covers the entire bibliography already made public in relation to the topic of study, allowing the researcher direct contact with what has already been written on the subject".

For the elaboration of this work, five fundamental authors stand out, presented in chronological order of publication: Chopra (2020), Kenneth and Jane Laudon (2020), Christopher (2020), Heizer and Render (2020), and J. Closs and Cooper (2021). These authors contributed significantly to the understanding of inventory management, covering everything from the supply chain to the use of technologies and the impacts on organizational performance.

3 THEORETICAL FOUNDATION

This rationale was organized into three topics. In the first, the importance of inventory planning within organizations was addressed, highlighting its relevance for cost control and for the proper functioning of operations. In the second, some of the main methods and techniques used in inventory control were presented. Finally, in the third topic, the impacts of inventory management on the performance of companies were discussed.

3.1 THE STRATEGIC IMPORTANCE OF INVENTORY PLANNING

Inventory planning is a fundamental activity for any organization that works with physical products. It is directly linked to the company's ability to serve its customers without generating waste or unnecessary costs.

According to Chopra (2020, p. 61), "inventory management directly influences supply chain performance, as it impacts both the level of customer service and operating costs."

In this sense, it is observed that efficiency in inventory management does not depend only on well-structured operational practices, but also on the support of technologies capable of integrating information, reducing uncertainties, and improving decision-making along the logistics chain.

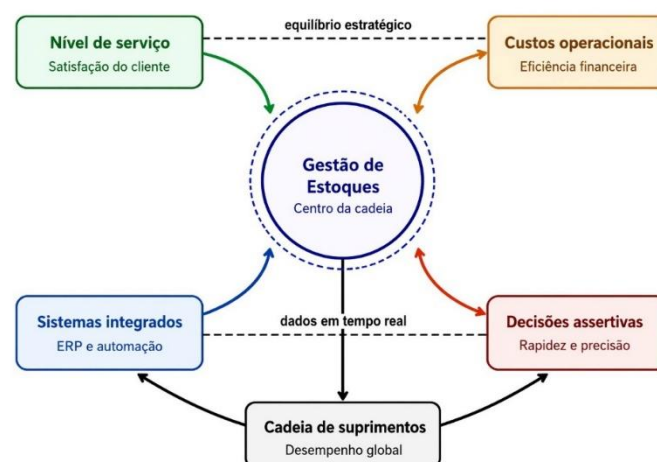
Laudon and Laudon (2020, p. 223) argue that: "Integrated systems help in the efficient management of resources and contribute to faster and more assertive decisions within organizations".

Inventory planning is considered to be directly associated with the overall performance of the organization, since it influences both storage costs and customer service capacity. In this context, it is highlighted that agility in service, especially the reduction of response time to demands, is an essential strategic factor for organizational competitiveness today.

Figure 1 below illustrates the central role of inventory management in balancing customer service level and operating costs, showing how the use of integrated systems and real-time data contributes to more assertive decisions and overall supply chain performance.

Figure 1

Strategic Pillars in the Supply Chain



Source: Reis e Prazeres (2024)

The analysis, presented in Figure 1, clearly and thoroughly emphasizes that inventory management plays an essential and strategic role in terms of supply chain performance. This happens because this administration is responsible for establishing a balance point, that is, it seeks to adequately harmonize the level of service provided to the customer, ensuring that their demands are met, with the operating costs borne by the company.

In this way, efficient inventory management becomes crucial to maximize both consumer satisfaction and the financial effectiveness of logistics processes. It is observed that the integration of different systems and the application of real-time data enhance the ability of institutions to react to different circumstances, culminating in decisions that are not only faster, but also more accurate. This decision-making dynamic proves vital for operational effectiveness as well as speed in the contemporary competitive context. Thus, the combination of these strategies is essential to improve the performance of organizations, enabling them to adapt effectively to the demands that constantly emerge (Zago; Stábile, 2026).

Thus, it is concluded that the adoption of systematic and structured practices aimed at planning and inventory management, when accompanied by appropriate technological support, not only favors the efficiency of operations, but also strengthens the competitiveness and sustainability of the results achieved by organizations over time. This underscores the relevance of an integrated strategy that promotes efficient performance over time.

3.2 INVENTORY CONTROL METHODS AND TECHNIQUES

For inventory to be well managed, companies use different control methods and techniques. Among the best known is the FIFO (First In, First Out), which prioritizes the exit of older products

According to Chopra (2020, p. 74), "the segmentation of inventory items helps in the prioritization of resources, allowing management to be more efficient and focused on the products with the greatest impact".

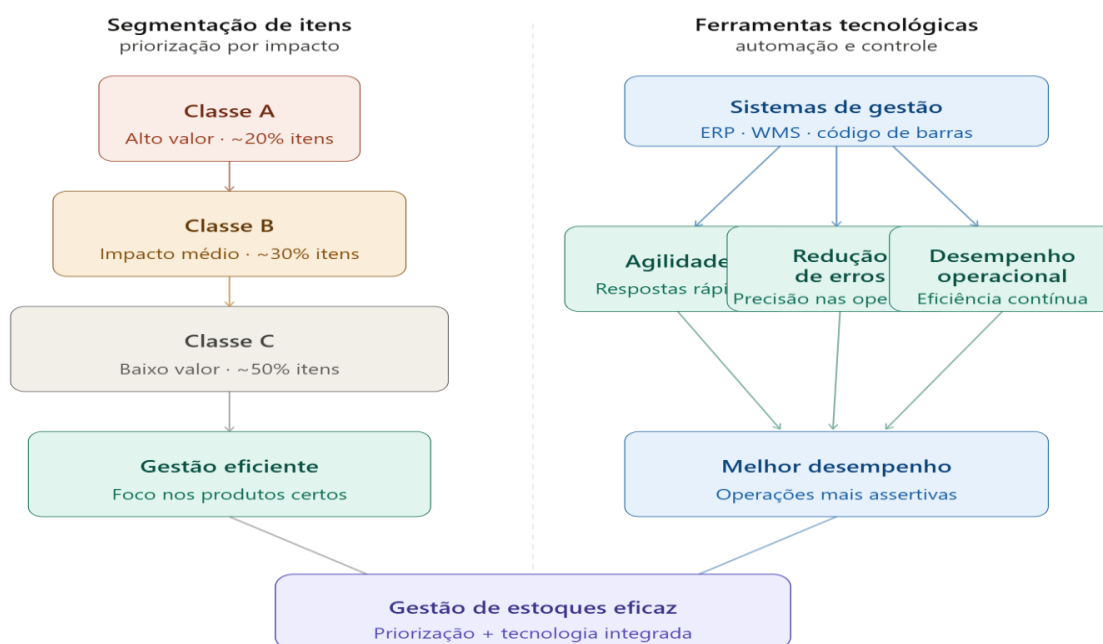
In this context, the definition of priorities based on the relevance of the items requires the support of mechanisms that ensure visibility, control, and agile processing of information, in order to support more accurate decisions aligned with the organization's strategic objectives.

According to Christopher (2020, p. 93), "the use of technological tools in inventory management allows for greater agility, reduction of errors, and better operational performance".

Nowadays, it is considered that inventory control methods and techniques are more than essential, but the human resource assigned to such tasks is still a bottleneck within organizations, especially in execution time.

Figure 2

Integration of the ABC curve with management systems



Source: Santos (2023).

Inventory management is a component of a business operation that strategically positions your business as a driver of system, process, cost, and customer service efficiency. Good control allows you to balance the availability of available product with the reduction of redundant products, so that there is no shortage or waste. ABC analysis and other tools help classify items, and integrated software such as ERP and WMS help ensure information accuracy and agility in operations. Thus, more effective inventory management leads to more assertive operations, better investment of resources, and increased competitive advantage of the business (Bravo, 2024).

3.3 IMPACTS OF INVENTORY MANAGEMENT ON ORGANIZATIONAL PERFORMANCE

The way inventory is managed can directly impact a company's bottom line. When there is good control, the organization can better serve its customers, avoiding delays and product shortages.

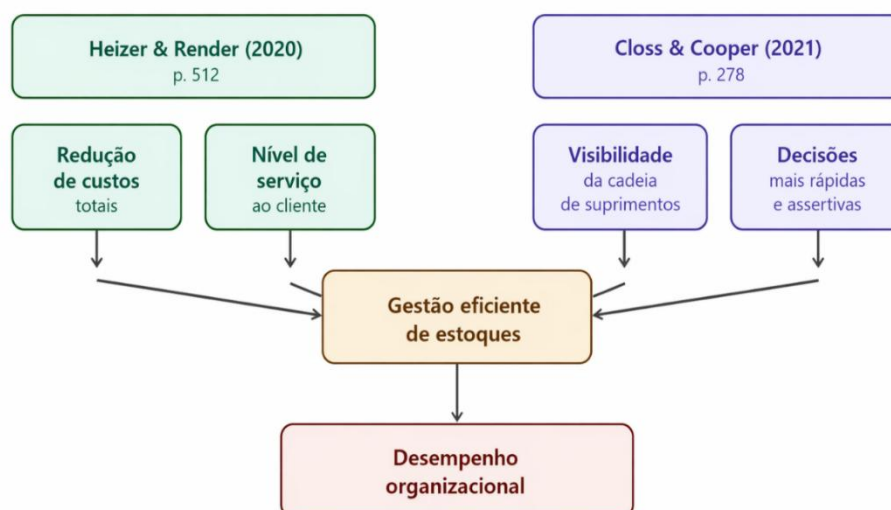
According to Heizer, Render and Munson (2020, p. 512), "efficient inventory management contributes to the reduction of total costs and improves the level of customer service, being essential for organizational performance".

As illustrated in Figure 3, effective inventory management is linked to the organization's performance, according to Heizer and Render (2020) and Closs and Cooper (2021). Of course,

good inventory management decreases total costs and increases the level of customer service, as well as increasing supply chain visibility and enabling faster and more accurate decisions. The figure, therefore, summarizes how the union of these elements translates into more effective management, directly reflecting on the results and competitiveness of companies.

Figure 3

Contributions of inventory management to organizational performance in the light of the literature



Source: Heizer and Render (2020); Closs and Cooper (2021)

According to Closs and Cooper (2021, p. 278), "proper inventory control provides greater visibility of the supply chain, allowing for faster and more assertive decisions."

It is considered that all Methods and Techniques of inventory control add to the final result, contributing to the Effectiveness of inventory control, it is necessary to have a management where it can be measured and monitored and evaluated.

As illustrated in Figure 3, effective inventory management is linked to the organization's performance, according to Heizer and Render (2020) and Closs and Cooper (2021). Of course, good inventory management decreases total costs and increases the level of customer service, as well as increasing supply chain visibility and enabling faster and more accurate decisions. The figure, therefore, summarizes how the union of these elements translates into more effective management, directly reflecting on the results and competitiveness of companies.

Figure 3 emphasizes that effective inventory management is a key component to the organization's performance. From the contributions of Operations Management, it can be seen that proper inventory control strategies reduce overall costs and improve customer service

levels. Inventory management provides the organization with more visibility into its supply chain and facilitates faster and more assertive decisions from a Supply Chain Management point of view. Thus, when these components are effectively integrated, it leads to more effective management and has a positive influence on the results and competitiveness of organizations.

4 FINAL CONSIDERATIONS

The final considerations of this study reaffirm that inventory planning and control are no longer understood as strictly operational activities, assuming a fundamental strategic role for the sustainability and competitiveness of organizations.

In the light of the theoretical foundation developed, it is evident that efficient inventory management is not limited to the monitoring of product inputs and outputs, but requires the adoption of structured practices and consolidated methodologies, such as ABC Curve, FIFO, Economic Purchase Lot (EOQ) and safety stock. In addition, the relevance of technological support is highlighted, through integrated systems, such as ERP and WMS, which enhance the accuracy of information, traceability and agility of decision-making processes.

In this context, it is observed that the impacts of inadequate inventory management go beyond the operational limits of the warehouse, directly reflecting on the financial performance, the level of customer service and the organization's ability to adapt to variations in demand.

The imbalance between excess and shortage of products is, therefore, a significant risk to the efficiency of the supply chain. In addition, there is a need for integration between inventory planning and other organizational areas, such as purchasing, production, logistics and finance, considering that isolated decisions tend to generate systemic inefficiencies. Thus, the adoption of an integrated view of the supply chain is an essential requirement for obtaining consistent and predictable results in inventory management.

In view of what has been exposed throughout this study, it is verified that the general objective was fully achieved, by evidencing the strategic relevance of planning and inventory control in organizations, as well as by demonstrating the importance of the main methods and techniques applied and their impacts on organizational performance.

In a complementary way, the specific objectives were also met, since the importance of inventory planning for operational efficiency and decision making was analyzed, widely used methodologies were described and examined, such as the ABC Curve, FIFO, EOQ and safety stock, in addition to consistently evaluating the effects of inventory management on fundamental indicators, such as costs, service level and competitiveness.

Finally, it is emphasized that the Supply Management professional must develop not only operational skills related to the use of control methodologies and instruments, but also a strategic understanding capable of articulating inventory data to managerial decisions and organizational objectives. Such competence is a relevant differential in the contemporary scenario, marked by high logistical complexity and growing demands for efficiency and responsiveness.

As a proposal for future investigations, it is suggested to carry out empirical studies that analyze the practical application of inventory management techniques in different economic sectors, allowing the comparison of results and the identification of best practices.

In addition, it is recommended to deepen the analysis of the role of emerging technologies, such as artificial intelligence, big data, and the Internet of Things (IoT), in the optimization of inventory control processes and supply chain integration. It is also pertinent to investigate the relationship between inventory management and sustainability, considering aspects such as waste reduction and efficiency in the use of resources, thus expanding the understanding of the strategic impacts of this area in the contemporary context.

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IMPLEMENTATION OF PARFOR AND PARFOR EQUITY AT UFMA: CONTRIBUTIONS AND LIMITS TO THE DEMOCRATIZATION OF TEACHER EDUCATION

IMPLANTAÇÃO DO PARFOR E DO PARFOR EQUIDADE NA UFMA: CONTRIBUIÇÕES E LIMITES PARA A DEMOCRATIZAÇÃO DA FORMAÇÃO DOCENTE

IMPLEMENTACIÓN DEL PARFOR Y DEL PARFOR EQUIDAD EN LA UFMA: CONTRIBUCIONES Y LÍMITES PARA LA DEMOCRATIZACIÓN DE LA FORMACIÓN DOCENTE



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ABSTRACT

Teacher education in basic education in Brazil has historically presented profound regional, social, and institutional inequalities, especially in states marked by educational vulnerabilities, such as Maranhão. In this context, public policies aimed at democratizing access to higher education become strategic for teacher appreciation and for improving the quality of basic education. The National Program for the Training of Basic Education Teachers (PARFOR) and, more recently, PARFOR Equity, were created to expand access to higher education for in-service teachers, prioritizing inland regions and historically marginalized groups. This study aimed to analyze the implementation processes of these programs at the Federal University of Maranhão (UFMA), highlighting their contributions and limitations regarding the democratization of teacher education. The research adopted a qualitative, descriptive, and exploratory approach, based on documentary analysis and bibliographic review. Institutional reports, legislation, public calls, and official documents from CAPES and UFMA were examined. The results indicate that the programs contributed to expanding access to teacher education courses, strengthening the interiorization of higher education, valuing cultural diversity, and reducing educational inequalities. Despite administrative, financial, and pedagogical challenges, PARFOR and PARFOR Equity demonstrate potential to consolidate equity policies and strengthen teacher education in Maranhão.

Keywords: Public Policies. Right to Education. Teacher Education. Basic Education. Educational Equity Management.

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RESUMO

A formação de professores da educação básica no Brasil apresenta, historicamente, profundas desigualdades regionais, sociais e institucionais, especialmente em estados marcados por vulnerabilidades educacionais, como o Maranhão. Nesse contexto, políticas públicas voltadas à democratização do acesso ao ensino superior tornam-se estratégicas para a valorização docente e para a melhoria da qualidade da educação básica. O Programa Nacional de Formação de Professores da Educação Básica (PARFOR) e, mais recentemente, o PARFOR Equidade, foram instituídos com a finalidade de ampliar o acesso de professores em exercício à formação superior, priorizando regiões interioranas e grupos historicamente marginalizados. Este estudo teve como objetivo analisar os processos de implementação desses programas na Universidade Federal do Maranhão (UFMA), destacando suas contribuições e limites para a democratização da formação docente. A pesquisa adotou abordagem qualitativa, de caráter descritivo e exploratório, fundamentada em análise documental e revisão bibliográfica. Foram examinados relatórios institucionais, legislações, editais e documentos oficiais da CAPES e da UFMA. Os resultados indicam que os programas contribuíram para a ampliação do acesso à licenciatura, fortalecimento da interiorização do ensino superior, valorização da diversidade cultural e redução de desigualdades educacionais. Apesar dos desafios administrativos, financeiros e pedagógicos, o PARFOR e o PARFOR Equidade evidenciam potencial para consolidar políticas de equidade e fortalecimento da formação docente no Maranhão.

Palavras-chave: Políticas Públicas. Direito a Educação. Formação Docente. Educação Básica. Gestão da Equidade Educacional.

RESUMEN

La formación de profesores de la educación básica en Brasil presenta históricamente profundas desigualdades regionales, sociales e institucionales, especialmente en estados marcados por vulnerabilidades educativas, como Maranhão. En este contexto, las políticas públicas orientadas a la democratización del acceso a la educación superior se vuelven estratégicas para la valorización docente y la mejora de la calidad de la educación básica. El Programa Nacional de Formación de Profesores de la Educación Básica (PARFOR) y, más recientemente, el PARFOR Equidad, fueron creados con el objetivo de ampliar el acceso de profesores en ejercicio a la formación superior, priorizando regiones del interior y grupos históricamente marginados. Este estudio tuvo como objetivo analizar los procesos de implementación de estos programas en la Universidad Federal de Maranhão (UFMA), destacando sus contribuciones y límites para la democratización de la formación docente. La investigación adoptó un enfoque cualitativo, de carácter descriptivo y exploratorio, fundamentado en análisis documental y revisión bibliográfica. Se examinaron informes institucionales, legislaciones, convocatorias y documentos oficiales de la CAPES y de la UFMA. Los resultados indican que los programas contribuyeron a ampliar el acceso a las licenciaturas, fortalecer la interiorización de la educación superior, valorizar la diversidad cultural y reducir las desigualdades educativas. A pesar de los desafíos administrativos, financieros y pedagógicos, el PARFOR y el PARFOR Equidad evidencian potencial para consolidar políticas de equidad y fortalecimiento de la formación docente en Maranhão.

Palabras clave: Políticas Públicas. Derecho a la Educación. Formación Docente. Educación Básica. Gestión de la Equidad Educativa.

1 INTRODUCTION

The training of basic education teachers in Brazil has a trajectory historically marked by regional inequalities, institutional limitations and disputes around the social function of education. Since the nineteenth century, when the first Normal Schools were created to prepare teachers for primary education, teacher training has developed unevenly, concentrating mainly in economically more favored regions and reaching only a restricted portion of the population. These first experiences of institutionalization of teaching took place in a context of organization of the national State and the gradual expansion of public education, but they maintained a strong elitist character and low territorial coverage, especially in the poorest provinces of the country.

Throughout the twentieth century, the expansion of basic schooling and the growth of public education networks significantly increased the demand for qualified teachers. With the creation of universities and higher education courses, an attempt was made to structure a national policy for teacher training, articulating pedagogical, scientific and specific knowledge of the teaching areas. However, educational expansion occurred in an accelerated way and often disconnected from the effective conditions of training and professional valorization. In different Brazilian regions, especially in the North and Northeast, thousands of teachers began to work without adequate training in the area in which they taught, revealing deep educational and structural asymmetries.

During this period, teacher training was linked to the political, economic and social transformations of the country, reflecting different projects of society and conceptions of education. At various times, fragmented training models prevailed, characterized by the separation between theory and practice, the precariousness of teaching work and the insufficiency of permanent policies for professional qualification. The need to expand basic education, especially from the 1970s and 1980s onwards, further highlighted the limits of the initial and continuing education offered to education professionals.

With the enactment of the Federal Constitution of 1988, education began to be recognized as a social right and duty of the State, strengthening the debate on teacher appreciation, quality of teaching and democratization of access to school. Subsequently, the Law of Guidelines and Bases of National Education (LDBEN No. 9,394/1996) established the requirement of higher education for the exercise of teaching in basic education, legally consolidating the need for professional teacher qualification. Despite the normative advances, the universalization of this right remained a challenge, especially in states marked by socioeconomic inequalities and difficulties in accessing higher education.

In view of this scenario, public policies for teacher training began to assume a strategic political role in confronting the historical inequalities of Brazilian education. Programs aimed at expanding the access of practicing teachers to higher education have become fundamental to promote professional qualification, strengthen public education networks and reduce regional disparities in the educational field.

In this context, the National Program for the Training of Basic Education Teachers (PARFOR) was instituted by the Coordination for the Improvement of Higher Education Personnel (CAPES) in 2009 as a government strategy to address the shortage of qualified teachers in the public network. The program sought to offer licentiate courses to practicing teachers who did not have specific training in the area of activity, ensuring them the legal qualification required by the current educational legislation. The national coverage of PARFOR made it possible to serve thousands of teachers in different regions, especially in inland and hard-to-reach locations, becoming a reference for public policy aimed at professional valorization and the strengthening of basic education. Its implementation contributed to the expansion of access to higher education and to the reduction of historical asymmetries between regions, although it has faced limitations related to the management, financing and continuity of actions.

PARFOR was part of a broader set of policies for the expansion and interiorization of higher education implemented in the first decades of the twenty-first century, a period marked by the expansion of federal universities, the creation of new campuses and the strengthening of educational inclusion programs. In this context, teacher training came to be understood not only as a technical requirement for professional practice, but as a strategy for social development, reduction of regional inequalities and strengthening of public education networks. The role of CAPES in coordinating the program has given greater national articulation to teacher training policies, promoting cooperation between the Union, states, municipalities and higher education institutions.

In 2023, the National Program for the Promotion of Equity in Basic Education Teacher Training (PARFOR Equidade) was instituted, also under the coordination of CAPES, in partnership with the Secretariat of Continuing Education, Youth and Adult Literacy, Diversity and Inclusion (SECADI/MEC). This new format emerged with the purpose of meeting the specific demands of teachers who worked in contexts of greater social, cultural and educational vulnerability. PARFOR Equity has incorporated an identity and inclusive dimension by offering courses aimed at quilombola communities, indigenous people, rural populations, people with disabilities and the deaf, recognizing diversity as a structuring element of education. This

proposal expanded the reach of traditional PARFOR by prioritizing historically marginalized groups, reinforcing the commitment to the democratization of teacher training on equitable and culturally contextualized bases.

The creation of PARFOR Equity also relates to contemporary discussions on social justice, interculturality, and recognition of differences in the educational field. In a country marked by ethnic-racial and territorial inequalities, universal policies have often proved insufficient to guarantee effective equality of access and permanence in higher education. Thus, the program began to incorporate principles aimed at recognizing the cultural and linguistic specificities of the subjects served, valuing traditional knowledge and promoting greater approximation between the university, local communities and contextualized educational practices.

At the Federal University of Maranhão (UFMA), the implementation of PARFOR began in 2009, with the offer of teaching degree courses in 37 municipalities in Maranhão. Throughout its history, the institution has become a protagonist in the consolidation of this public policy in the region, responding to historical demands for teacher training and expanding the access of basic education professionals to the university. In 2024, UFMA also started the execution of PARFOR Equity, structuring degree courses in areas such as Quilombola School Education, Indigenous Intercultural Education, Inclusive Special Education and Bilingual Education for the Deaf. Such courses were planned based on articulation with local communities, schools and managers, seeking to respect cultural specificities and promote greater integration between the university, the educational system and the populations served. The insertion of PARFOR and PARFOR Equity in UFMA highlights not only the strategic role of the institution in the state, but also the challenges inherent to management, financing and pedagogical monitoring.

In the context of Maranhão, such programs assume even greater relevance in view of the historical indicators of social inequality, territorial dispersion and difficulties in accessing higher education. Maranhão has a significant concentration of rural municipalities, traditional communities and regions with low human development indexes, factors that have historically impacted the training of basic education teachers. In this scenario, UFMA's performance through PARFOR and PARFOR Equity represents an important strategy for university interiorization, contributing to bring public higher education closer to populations historically excluded from training processes.

In view of this scenario, the following guiding question was formulated: what is the importance of the implementation of PARFOR and PARFOR Equity in the state of Maranhão,

in terms of educational management and democratization of teacher training in basic education?

To answer this question, the general objective of the research was to analyze the processes of implementation of PARFOR and PARFOR Equity at UFMA, highlighting how educational management contributed to the promotion of equity. The specific objectives consisted of: investigating the history of public policies for teacher training in Brazil and Maranhão; identify management strategies adopted by UFMA in the implementation of PARFOR and PARFOR Equity; know the organizational structure of the programs in the institution; and to evaluate the contributions and limits of these actions for the democratization of access to higher education by public school teachers.

The methodology adopted a qualitative approach, with a descriptive and exploratory character, based on documentary analysis and bibliographic review. Legislation, public notices, institutional reports of UFMA and academic productions related to PARFOR and PARFOR Equity were examined, allowing us to understand the implementation processes, the structure of the courses and the management mechanisms adopted. The investigation sought to articulate official data and specialized literature to identify the strategies for democratization of teacher training, the challenges faced and the results of the two programs, providing subsidies for the critical evaluation of the contributions in the context of Maranhão.

The research presented in this article is organized into five sections. After this introduction, the second section describes the methodology adopted, detailing procedures, sources and analysis steps. The third section examines the historical, legal and political context of teacher training in Brazil and Maranhão, addressing the creation of PARFOR and PARFOR Equity and situating their incorporation into UFMA, as well as the regional and structural challenges for the qualification of basic education teachers. The fourth section analyzes the implementation of these programs at the university, divided into subsections that deal with the operationalization of PARFOR at UFMA and the management of PARFOR Equity, considering courses offered, centers served, number of enrollments, profile of faculty-students, institutional strategies and main obstacles. Finally, the fifth section presents the final considerations, synthesizing the impacts of PARFOR and PARFOR Equity on the democratization of teacher training in Maranhão and pointing out opportunities to improve public policies aimed at educational equity.

2 METHODOLOGY

The rigorous understanding of any social or educational phenomenon depends directly on the clarity and adequacy of the methodology employed. According to Gil (2019), scientific methodology consists of the set of procedures used to achieve research objectives in a systematic and reliable way, allowing the results to be analyzed and interpreted critically. Lakatos and Marconi (2017) highlight that the methodological choice guides the collection, analysis, and interpretation of data, being fundamental to confer validity and consistency to the study. In this sense, the methodology is not limited to indicating techniques, but establishes the paths for the production of knowledge, ensuring that the research processes are replicable and subject to scientific evaluation. This research, therefore, is based on methodological principles that ensure rigor, transparency and social relevance, offering a clear overview of the procedures adopted to analyze the implementation of PARFOR and PARFOR Equity at UFMA.

The general objective of the research is to analyze the processes of implementation of PARFOR and PARFOR Equity at UFMA, highlighting how educational management contributed to the promotion of equity. The specific objectives consisted of: investigating the history of public policies for teacher training in Brazil and Maranhão; identify management strategies adopted by UFMA in the implementation of PARFOR and PARFOR Equity; know the organizational structure of the programs in the institution; and to evaluate the contributions and limits of these actions for the democratization of access to higher education by public school teachers.

To achieve these objectives, the research used a qualitative approach, with a descriptive and exploratory character, based on documentary analysis and bibliographic review, classic methods and widely recommended by authors such as Gil (2019) and Severino (2017) for investigations in applied social sciences. The qualitative approach proved to be adequate because it enables an in-depth understanding of institutional processes, management practices and educational dynamics that cannot be reduced to numerical indicators alone. According to Minayo (2014), qualitative research works with the universe of meanings, social relations, representations and interpretations produced by subjects and institutions, allowing the understanding of complex phenomena inserted in specific historical and sociocultural contexts.

The descriptive character of the investigation sought to identify and systematize information regarding the implementation of the programs, the administrative strategies adopted by the university, the territorial distribution of the courses and the mechanisms of democratization of access to teacher training. The exploratory dimension, on the other hand, allowed us to broaden the understanding of an object that is still recent and in the process of consolidation, especially in the case of PARFOR Equity, whose implementation at UFMA took

place from 2024 onwards. In this sense, the research sought not only to describe institutional data, but also to critically interpret the political, social and educational meanings of these initiatives in the context of Maranhão.

The documentary analysis included ordinances, enrollment reports, course planning and institutional data from the Ministry of Education, CAPES and UFMA, while the bibliographic review allowed contextualizing the results based on consolidated academic production. Official documents related to national teacher training policies, educational legislation, selection notices, institutional resolutions, academic reports and administrative documents produced by the university and the federal agencies responsible for coordinating the programs were examined. The use of these sources made it possible to understand both the normative aspects and the concrete processes of operationalization of PARFOR and PARFOR Equity at UFMA.

The literature review focused on studies on public educational policies, teacher training, educational management, democratization of higher education and equity in education. Authors who discuss teacher training in the Brazilian context were mobilized, as well as research focused on policies for the interiorization of higher education and regional inequalities in education. This articulation between institutional documents and specialized literature allowed us to build a broader analysis of the impacts and limits of the programs investigated.

The analysis of the documents followed systematic steps: survey and careful selection of sources, categorization of information into central themes (implementation strategies, access of teachers from remote regions and impacts on training), critical synthesis in the light of the literature and identification of gaps and challenges. Initially, the mapping of the documentary sources available in the institutional portals of CAPES, the Ministry of Education and UFMA was carried out. Then, the documents were organized according to their nature and purpose, allowing the identification of information related to the creation of the programs, curricular organization, administrative management, number of vacancies offered, municipalities served and profile of the participating teachers.

Subsequently, an analytical reading of the material was carried out, seeking to identify recurrent categories related to the democratization of access to higher education, the internalization of teacher training, the promotion of equity and institutional challenges faced by the university. This stage allowed us to understand the relationships between public policies, university management and specific social demands of the Maranhão context. The interpretation of the data was carried out in conjunction with the bibliographic review, making it possible to confront the official documents with the theoretical discussions produced in the educational field.

This methodological sequence made it possible to understand the interrelations between educational management, democratization of teacher training and promotion of equity, ensuring coherence and analytical depth. The qualitative approach allowed the evaluation of both quantitative aspects, such as the number of classes and enrollments, as well as qualitative dimensions related to academic management, pedagogical monitoring and articulation with local sociocultural contexts, ensuring reliability and validity of the results (Lakatos; Marconi, 2017; Gil, 2019). In addition, the combined use of documentary analysis and literature review contributed to expanding the interpretative consistency of the research, allowing the programs to be examined not only as administrative initiatives, but as public policies linked to debates on the right to education, social justice and reduction of educational inequalities.

The methodology adopted offered a rigorous approach to understand the implementation of PARFOR and PARFOR Equity at UFMA. The documentary analysis and the literature review allowed for a critical evaluation of the contributions and limitations of the programs, subsidizing the improvement of public policies, educational management and the promotion of equity. By articulating theoretical foundations, institutional documents and critical analysis of teacher training policies, the research sought to contribute to the debate on the democratization of higher education and the valorization of basic education professionals in contexts historically marked by social and regional inequalities. This systematization created the basis for analyzing the historical trajectory and current practices of teacher education in Brazil and Maranhão, confronting legislation and reality, a theme that will be explored in the next section.

3 TEACHER TRAINING IN BRAZIL AND MARANHÃO

This section aims to analyze the historical and legal trajectory of teacher education in Brazil and Maranhão. Seeking to understand how public policies and legal frameworks have shaped teacher training, allowing to contextualize the implementation of PARFOR and PARFOR Equity at UFMA, in line with the specific objectives of the research. This analysis is fundamental to identify how educational legislation has influenced access to teacher training and the promotion of equity in basic education.

In the colonial period, education was essentially religious and restricted to the elites, with the Jesuits playing a central role in basic instruction and in the training of future teachers, centered on catechesis and the maintenance of social order (Faustino, 2001; Carvalho, 2003). Teacher training was informal and limited, marked by the scarce supply of schools and the absence of specific government regulations for popular education.

In this context, the work of the Society of Jesus structured an educational model aimed at moral and religious formation, in which teaching had as its main purpose the consolidation of Portuguese colonial domination. The preparation of the masters occurred predominantly through practical experience and religious orientation, and there were no systematic public policies aimed at professional teacher training. As Saviani (2013) observes, Brazilian colonial education was characterized by social exclusion and the absence of an educational system organized by the State.

Independence and the Empire brought the creation of rudimentary norms, such as the Regulation of 1827, which established the first standards for normal schools and the training of primary teachers, but in a way that was still elitist and concentrated in the capitals, leaving the interior practically unassisted (Saviani, 2013). The Law of October 15, 1827 represented an important legal milestone in establishing guidelines for schools of first letters, but its limitations revealed the country's structural difficulties in universalizing public education. The first Normal Schools, created from the 1830s onwards, sought to prepare teachers for elementary education, but remained concentrated in large urban centers and served a small number of students. Tanuri (2000) points out that these institutions contributed to the institutionalization of teacher training in Brazil, although they still maintained a strong selective and elitist character.

During the Old Republic (1889-1930), educational reforms sought to expand access to education, but teacher training maintained centralizing and regionally differentiated characteristics. Normal schools continued to prioritize formal content and the reproduction of traditional knowledge, while Maranhão faced structural difficulties in ensuring quality teacher training, reflecting historical inequalities in infrastructure and human resources (Gatti, 2010; Oliveira, 2008).

During this period, positivist influences and the ideals of modernization of the State boosted debates on the need to expand public education, but educational policies continued to be marked by deep regional inequalities. While states in the Southeast had a greater expansion of normal schools and investments in education, Maranhão remained with a reduced supply of training institutions and low schooling rates. The precariousness of the material conditions of the schools and the scarcity of qualified teachers made it difficult to consolidate more comprehensive educational policies.

The Vargas Era (1930-1945) introduced measures to centralize and professionalize teacher training, with the creation of teaching schools and normal courses in various regions. Despite expanding the offer of courses, the actions still favored urban centers, and training continued to be restricted to authoritarian and content-based models (Saviani, 2013). The

creation of the Ministry of Education and Public Health in 1930 marked the beginning of a more nationally articulated educational policy, but the reality in Maranhão still reflected significant gaps in teacher training and school infrastructure.

The reforms inspired by the New School movement began to defend teacher training based on more modern scientific and pedagogical principles, emphasizing active methodologies and greater appreciation of childhood and the educational process. However, such proposals reached the different Brazilian states in an unequal way, keeping Maranhão distant from the main experiences of pedagogical renewal developed in the country.

During the military regime (1964-1985), education underwent reforms aimed at quantitative expansion and technical training, with the creation of institutes and programs aimed at the rapid professionalization of teachers, but with little investment in pedagogical quality (Dourado, 2015). The LDBEN of 1961 and subsequent decrees sought to regulate teacher training, but the emphasis remained on basic education focused on literacy and discipline, neglecting critical training and regional equity. Maranhão, like other peripheral regions, remained with limited access to continuing education courses and specialized training.

In this context, a technicist perspective of education predominated, focused on administrative rationalization and the preparation of labor for economic development. Many emergency programs were implemented to quickly address the shortage of teachers, especially in inland regions, but without ensuring adequate conditions for pedagogical training. As Dourado (2015) analyzes, the quantitative expansion of education during the military regime often occurred dissociated from consistent policies of teacher appreciation and educational quality.

With the enactment of the Federal Constitution of 1988, education became a fundamental right, ensuring equal conditions and the duty of the State to offer adequate training for all basic education teachers. LDBEN 9.394/1996 consolidated principles of democratization and quality, defining guidelines for the initial and continuing training of teachers and establishing minimum standards of schooling and professional qualification (Saviani, 2013; Gatti, 2010). In Maranhão, these norms represented significant advances, especially with the expansion of university centers and continuing education programs, but regional inequality and infrastructure limitations still constituted important barriers to the full implementation of public policies.

The Federal Constitution of 1988 redefined education as a social right and broadened the debate on valuing teaching, quality of teaching and democratization of access to school. Subsequently, LDBEN No. 9,394/1996 established the requirement of higher education for the exercise of teaching in basic education, legally strengthening the need for teacher

professionalization. Despite these legal advances, challenges persisted related to the internalization of higher education, student permanence, and teacher training in rural municipalities and socially vulnerable regions.

Classic authors of teacher training, such as Gatti (2010), Saviani (2013) and Oliveira (2008), emphasize that, although Brazilian legislation has evolved continuously, the practical application in the national territory has revealed profound regional differences. In Maranhão, the gap between legislation and the daily practice of schools highlighted the need for programs that considered local specificities and historical challenges, providing support to teachers in practice and expanding access to higher education. This historical reality justifies the creation of policies such as PARFOR and, more recently, PARFOR Equity, aimed at the democratization of teacher training, especially for teachers who work in municipalities in the interior.

In this sense, public policies for teacher training began to assume a strategic role in reducing educational inequalities and strengthening public education networks. PARFOR and PARFOR Equity are part of this context as initiatives aimed at expanding access to licensure, professional valorization and the promotion of educational equity, especially in states historically marked by structural difficulties, such as Maranhão.

Therefore, the trajectory of teacher training in Brazil and Maranhão reveals a historical process of legal advances that, however, is confronted with practical challenges, such as regional inequality, lack of infrastructure and concentration of resources. Legislation has evolved from rudimentary instruments in the colonial period to constitutional and legal frameworks that ensure the right to education and qualified teacher training, but the effectiveness of these norms depends on the implementation of contextualized public policies. This historical and legal analysis provides the necessary foundation to understand the most recent processes of teacher training, a theme that will be deepened in subsequent sections, especially in the study of PARFOR and PARFOR Equity at UFMA.

4 PROCESSES FOR IMPLEMENTING PARFOR AND PARFOR EQUITY IN BRAZIL

Continuing the historical and legal analysis of teacher training in Brazil and Maranhão, presented in the previous section, this section aims to examine the processes of creation and implementation of PARFOR and PARFOR Equity, highlighting their relevance in the national scenario and their subsequent incorporation by UFMA. While section three broadly situated the historical and legislative context of teacher education, here we seek to understand the operationalization of these public policies, analyzing institutional strategies, the geographical

distribution of courses, academic management and the mechanisms of inclusion of historically marginalized groups.

The National Plan for the Training of Basic Education Teachers (PARFOR) was instituted in 2009, in the context of the expansion of federal education policies, through Decree No. 6,755, of January 29, 2009, and regulated by Normative Ordinance MEC/CAPES No. 40/2009 (Brasil, 2009; CAPES, 2009). Its creation was motivated by the worrying situation revealed by the National Institute of Educational Studies and Research Anísio Teixeira (INEP), which indicated that about 40% of the teachers in office in the country did not have specific qualifications for the area in which they taught (INEP, 2009). This reality mainly affected schools located in peripheral, rural regions with low socioeconomic development, especially in the North and Northeast of Brazil, where the shortage of licensed teachers was more pronounced.

The program was born within the scope of the Education Development Plan (PDE, 2007) and the goals of the National Education Plan (PNE 2001–2010), which emphasized the urgency of valuing teachers and the universalization of higher education for basic education teachers. In addition to meeting the training deficit, PARFOR sought to create conditions for the strengthening of the teaching career, articulating goals for the expansion of higher education to the specific demands of the municipal and state education networks (Gatti, 2011; Libâneo, 2013).

Among its main objectives were: to expand the offer of licentiate courses under special regimes, to prioritize municipalities with a historical deficit of qualified teachers, to reduce regional inequalities in access to higher education and to contribute to the valorization of teaching as a profession of the State. In its first decade of operation, PARFOR mobilized 90 public institutions of higher education, including federal, state and federal universities, reaching approximately 334 thousand teachers enrolled in teaching degree courses, distributed in more than 3 thousand Brazilian municipalities. Until 2016, data from CAPES (2017) indicated that more than 300 thousand professors entered classes of the program, with an average completion rate of more than 70%, a significant result given the historical difficulties of permanence in higher education faced by professors in practice. During this period, the program offered about 51 thousand vacancies per year, in more than 2,500 service centers, prioritizing locations with a low Human Development Index (HDI) and a high deficit of qualified professionals.

PARFOR represents, therefore, a policy of a strategic nature, by combining a logic of federative integration, mobilizing universities, federal institutes, states and municipalities, with a focus on reducing regional inequalities. This configuration allows teachers from public schools in rural, quilombola, indigenous, riverside and peripheral urban areas to have access to

licensure training, in many cases offered in the municipality itself or in centers that are easy to travel. By creating a cooperation network between the Union, states, and municipalities, the program broke with the tradition of fragmented training policies, which historically disregarded local specificities (Dourado, 2020).

PARFOR Equity, established in 2022 within the scope of the Coordination for the Improvement of Higher Education Personnel (CAPES), emerged as an unfolding and improvement of previous policies. Aimed primarily at teachers belonging to historically marginalized social groups, indigenous people, quilombolas, blacks, people with disabilities, and rural education teachers, the program sought to ensure not only access to higher education, but also the construction of training proposals sensitive to cultural and territorial specificities (CAPES, 2022). This aspect of PARFOR expands the dimension of equity, incorporating the right to difference and social justice into teacher training policies, in line with the principles established by the National Education Plan 2014–2024, especially goal 15, which provides for ensuring specific higher education training for all basic education teachers.

The creation of PARFOR Equity also dialogues with international commitments assumed by Brazil, such as the Sustainable Development Goals (SDGs) of the UN 2030 Agenda, in particular SDG 4, which establishes ensuring inclusive, equitable and quality education. By directing public policies to historically excluded segments, PARFOR Equity materializes a qualitative advance in relation to the first phase of the program, reinforcing the need to reconcile quantitative expansion of vacancies with contextualized training, which respects the sociocultural diversities of the country (Souza; Amaral, 2022).

Thus, both PARFOR and PARFOR Equity should be understood as structuring initiatives in the field of teacher training, which go beyond compensatory actions to address historical deficits. The first consolidated a national network for the offer of degrees in a special regime, expanding the presence of higher education in underserved regions and guaranteeing qualification to hundreds of thousands of teachers. The second, by introducing the principle of equity, reaffirms the commitment that access to training should be universal, but also differentiated and sensitive to local realities. This evolution demonstrates that the public policy of teacher training in Brazil has sought, albeit with limits, to align itself with principles of democratization, valorization and social justice.

4.1 FROM NATIONAL POLICY TO INSTITUTIONAL PRACTICE: PARFOR AT UFMA

Maranhão, a state historically marked by critical educational indicators, has been present since the initial phase of implementation of the National Plan for the Training of Basic Education

Teachers (PARFOR). With low school performance rates, illiteracy rates above the national average and a high concentration of teachers without higher education, the adherence of the Federal University of Maranhão (UFMA) to the program in 2009 represented a milestone for the democratization of teacher training in the region (INEP, 2010; UFMA, 2023).

UFMA was one of the first federal universities to incorporate PARFOR, offering undergraduate courses in strategic areas such as Mathematics, Portuguese Language, History, Biological Sciences and Pedagogy, aiming to meet historical shortcomings in the public education system. To ensure territorial reach, support centers were structured in strategic municipalities such as Imperatriz, Bacabal, Caxias, Pinheiro, and São Luís, with classes organized in an intensive regime, in order to enable the participation of teachers in practice, many of them from regions far from the capital (UFMA, 2020).

In the first phase of the program, between 2009 and 2016, the university offered about 4,200 vacancies in undergraduate degrees, of which more than 3,000 resulted in successful conclusions, corresponding to approximately 72% of the completion rate (UFMA, 2023). The operationalization of PARFOR involved different stages, such as a survey of regional demands, identification of teachers without full qualification, definition of priority courses, distribution of classes and centers, allocation of teacher trainers and tutors, continuous pedagogical monitoring and institutional evaluation of results. The process involved the performance of UFMA professors who, in addition to regular teaching, research and extension activities, assumed additional responsibilities in the execution and pedagogical monitoring of the program.

However, since its early years, some structural challenges have been pointed out. The discontinuity of federal funding compromised the regularity of the opening of classes; the articulation between the university and municipal departments of education has not always been effective, especially in smaller municipalities; student dropout rates presented worrying rates in certain centers, reaching up to 25% in more vulnerable locations; and university professors reported work overload due to the intensification of teaching activities in the interior (Gatti; Barreto, 2015; Brito, 2017; Silva, 2020).

Despite these obstacles, UFMA has consolidated itself as a reference in Maranhão for the interiorization of higher education, articulating PARFOR with local educational policies and ensuring the titles of thousands of teachers from the public network. The impact of this policy can be observed in the expansion of the number of licensed teachers, in the expansion of access to higher education in traditionally excluded regions and in the valorization of the teaching profession, even in the midst of difficulties of permanence and financing.

As the policy matured, criticism arose about the insufficiency of the generalist model of PARFOR to address deeper inequalities. Internal UFMA reports and evaluation studies indicated that, although there was significant adherence of public school teachers, quilombola communities, indigenous people, deaf teachers and people with disabilities continued to face barriers to access and permanence. These barriers ranged from linguistic and cultural issues to infrastructure limitations at the hubs, reinforcing historical inequalities (UFMA, 2023).

In this scenario, CAPES launched, in 2022, PARFOR Equity, regulated by Ordinance No. 206, as a policy aimed specifically at teacher training of historically marginalized groups. Unlike the original PARFOR, which was organized around a wide range of teaching degrees, PARFOR Equity focused on specific areas: Quilombola School Education, Indigenous Intercultural Education, Inclusive Special Education, and Bilingual Education for the Deaf, in line with the principles of the 1988 Federal Constitution, the LDB (Law No. 9,394/1996), and the goals of the National Education Plan (2014–2024).

UFMA officially joined PARFOR Equity in 2024, reinforcing its tradition of interiorization and expanding the reach of the policy. 12 initial action centers were established, distributed in municipalities with a strong presence of quilombola and indigenous communities, such as Alcântara, Caxias, Grajaú, Zé Doca and Santa Inês (UFMA, 2024). In this first stage, 1,200 vacancies were opened in teaching degree courses focused on the cultural and linguistic specificities of these groups, with classes organized in an intensive regime and adapted to the socioeconomic conditions of the teacher-students.

The profile of the students evidenced the relevance of the policy: 70% were women, 45% quilombolas, 25% indigenous and 15% people with disabilities, in addition to the significant presence of teachers working in rural schools (UFMA, 2024). These data reveal an important shift in relation to the traditional PARFOR, by directing efforts to audiences often made invisible by teacher training policies.

From the point of view of management, UFMA created a specific institutional structure, coordinated by the Dean of Education (PROEN) and the Interiorization Advisory, with responsibilities that included: selection of teacher trainers, logistical support to the centers, articulation with municipal secretariats and pedagogical monitoring. Even so, relevant difficulties persisted, such as precarious infrastructure in inland centers, limited connectivity, overload of university professors, and an average dropout rate of 18% in the first year, mainly related to adverse socioeconomic conditions and the reconciliation between work and study.

As a response, the university and local partners implemented mitigation strategies, such as partnerships with city halls and community associations for transportation and food,

continued training of teacher-trainers in intercultural and bilingual methodologies, psychopedagogical monitoring aimed at indigenous and deaf students, in addition to semiannual reports sent to CAPES, ensuring greater transparency and continuous evaluation.

The preliminary results were expressive. By the end of 2024, 920 teachers had successfully completed the first year of the course, achieving a permanence rate of more than 80% (UFMA, 2024). This index, although still insufficient, was considered positive in the face of adverse conditions, signaling the potential of the program to consolidate higher education trajectories among teachers from historically marginalized communities. In addition, UFMA's experience became nationally recognized, with the presentation of reports and good practices in seminars promoted by CAPES and the National Education Forum (FNE, 2024).

However, the trajectory of PARFOR at UFMA, from the initial adhesion in 2009 to the incorporation of PARFOR Equity in 2024, illustrates a movement of evolution in public policy: from massive training of teachers in practice to a focused, equitable and culturally contextualized training. At the same time that it maintains its function of expanding the teaching title in the state, the university reaffirms its centrality in the fight against social and educational inequalities, internalizing access to higher education and incorporating inclusive pedagogical practices. Although it faces structural and financing challenges, the program shows promise for building a more representative education, in line with the principles of equity and social justice.

The following section will deepen the management and implementation processes of PARFOR Equity at UFMA, highlighting the courses offered, the centers served, the profile of the students and the institutional strategies to overcome the challenges that still arise.

4.2 MANAGEMENT AND OPERATIONALIZATION OF PARFOR EQUITY AT UFMA

This subsection presents the analysis of the management and operationalization of PARFOR Equity at the Federal University of Maranhão (UFMA), with the central objective of demonstrating how the institution structured, monitored and adapted the program to regional specificities, promoting access to higher education for teachers in practice in historically disadvantaged contexts. The investigation considers organizational, pedagogical and logistical aspects, allowing us to understand how national teacher training policies are articulated with local demands, ensuring the inclusion of indigenous teachers, quilombolas, people with disabilities and deaf people (UFMA, 2024; CAPES, 2022). To this end, the analysis uses institutional data from UFMA, CAPES reports and recent studies on teacher training and public policies, identifying institutional strategies and results of the action.

The implementation of PARFOR Equity at UFMA began in 2024, with the creation of 12 regional hubs strategically distributed in municipalities with a high concentration of historically marginalized populations, including Alcântara, Caxias, Grajaú, Zé Doca and Santa Inês (UFMA, 2024). For this first phase, 1,200 vacancies were opened in specific degree courses, including Quilombola School Education, Indigenous Intercultural Education, Inclusive Special Education and Bilingual Education for the Deaf. The distribution of classes sought to meet local demands, considering the geographical distance, the availability of infrastructure and the density of teachers in office, promoting qualified access to higher education in regions with difficult educational coverage.

The program mobilized about 120 UFMA professors, acting as tutors, coordinators, and teacher trainers at the centers, accumulating teaching, research, and extension functions, and ensuring continuous pedagogical monitoring (UFMA, 2024). This institutional articulation allowed the implementation of pedagogical strategies adapted to the sociocultural realities of the students, such as intercultural, bilingual and inclusive methodologies, as well as psychopedagogical monitoring aimed at indigenous, quilombola and deaf teachers, in order to reduce linguistic and cultural barriers to learning.

The profile of the enrolled students highlights the social relevance of the initiative: 70% are women, 45% quilombolas, 25% indigenous and 15% people with disabilities, with a significant presence of teachers working in rural schools and rural communities (UFMA, 2024). The adhesion of the faculty demonstrates the impact of the program in reducing historical inequalities in access to academic training, promoting social inclusion and valuing cultural diversity in basic education.

In terms of management and operationalization, UFMA has structured a support network integrated with the Dean of Education (PROEN) and the Interiorization Advisory, responsible for the academic and logistical coordination of the centers, selection and training of teacher trainers, articulation with municipal education departments and continuous monitoring of classes. Among the mechanisms adopted, the continuing education of tutor teachers, the implementation of biannual evaluation processes, partnerships with city halls and community associations for transportation and food, and technological support for classes and teaching materials stand out. This structure evidenced the university's ability to reconcile national policies with local demands, promoting a model of interiorization of higher education focused on equity (UFMA, 2024; CAPES, 2022).

PARFOR Equity presents significant advances in relation to the first phase of PARFOR, by concentrating efforts on historically marginalized groups and recognizing the regional and

cultural specificities of the participants. Recent studies indicate that structured teacher training programs, such as PARFOR and PARFOR Equity, are strategic for overcoming historical inequalities, strengthening the professionalization of teachers and improving the quality of teaching in basic education (Dourado, 2020; Souza; Amaral, 2022). By integrating national policies and local demands, the program highlights a model of educational inclusion adapted to contexts of socioeconomic and territorial vulnerability, consolidating the social function of the public university in promoting equity.

The challenges faced in the implementation include precarious infrastructure in some centers, limited connectivity, overload of professors, and initial dropout of about 18% of the students in the first year, motivated by socioeconomic difficulties and reconciliation between work and study (UFMA, 2024). To mitigate them, UFMA has developed integrated strategies, including: continued training of tutors in intercultural and bilingual methodologies; individualized psychopedagogical follow-up; logistical support through partnerships with municipal secretariats and community associations; and systematic monitoring of execution, with reports sent to CAPES, ensuring transparency and constant evaluation of the results. Such measures demonstrate how institutional management can enhance the effectiveness of public policies, ensuring the permanence and academic success of the participating professors.

The results obtained until 2024 reveal concrete impacts on the democratization of access to teacher training in Maranhão. Approximately 920 professors successfully completed the first year of implementation, with a permanence rate of more than 80%, expressive numbers given the socioeconomic and geographical conditions faced by the students (UFMA, 2024). The equitable distribution of centers and courses has made it possible to serve areas with a greater historical deficit of licensed teachers, strengthening the teaching of the state and municipal public network and expanding the presence of qualified professionals in remote and vulnerable regions.

Thus, the management and operationalization of PARFOR Equity at UFMA demonstrates that public policies for teacher training, when well structured and articulated with regional specificities, can promote inclusion, equity and quality in higher education. The program contributes to reducing historical inequalities by enabling teachers in practice, especially in peripheral municipalities and traditional communities, to have access to degrees. Among the impacts already identified, the increase in enrollment in strategic areas, the strengthening of local education networks, the appreciation of cultural and linguistic diversity in teacher training and the incorporation of intercultural and inclusive pedagogical practices stand out.

PARFOR Equity evidences, still in its early steps, the social function of UFMA as an agent of interiorization of higher education, although its initial results indicate more potentialities than consolidations, evidencing the need for more stable, integrated and sustainable policies. In this sense, the experience of Maranhão reinforces that programs aimed at teacher training, if accompanied by consistent monitoring and support mechanisms, can become relevant instruments for professional valorization and for the reduction of educational inequalities. These analyses support the transition to the final considerations, which will resume the contributions of PARFOR and PARFOR Equity to the democratization of teacher training in Maranhão and Brazil, synthesizing the impacts achieved and pointing out ways to improve public policies.

5 FINAL CONSIDERATIONS

This research started from the central question: what is the importance of the implementation of PARFOR and PARFOR Equity in the state of Maranhão, in terms of educational management and democratization of basic education teacher training?

Throughout the sections, it was possible to demonstrate that both PARFOR and PARFOR Equity play a unique and strategic role in expanding access to higher education and valuing teaching, contributing to reducing historical inequalities in the state. The investigation also showed that these public policies go beyond the strictly academic dimension, assuming social, territorial and cultural relevance in the consolidation of the right to education in regions historically marked by educational vulnerabilities and exclusion from higher education.

Since its implementation in 2009, PARFOR at UFMA has trained 2,907 teachers in practice, distributed in 127 classes offered in 34 municipalities in Maranhão. Currently, the program is present in 42 municipalities, with 94 classes and more than 4,300 students enrolled, covering seven undergraduate courses. These numbers show the capacity for higher education to move to the interior and the positive impact on teacher training in several regions of the state. More than quantitative indicators, these data reveal the strengthening of the presence of the public university in municipalities in the interior historically distant from higher education policies. In many of these territories, the arrival of PARFOR represented the first concrete opportunity for teachers to access a teaching degree for practicing teachers, especially in rural locations and municipalities far from large urban centers.

PARFOR Equity, started in 2024, broadened the focus of the policy, directing training to teachers belonging to historically marginalized groups, such as indigenous people, quilombolas, people with disabilities, and the deaf. In the first stage of the program, 1,200 vacancies were offered in 12 centers distributed in municipalities such as Alcântara, Caxias, Grajaú, Zé Doca

and Santa Inês. Institutional data indicate that, by the end of 2024, 920 teachers had successfully completed the first year of specific courses in Quilombola School Education, Indigenous Intercultural Education, Inclusive Special Education and Bilingual Education for the Deaf, with a permanence rate of more than 80%. This number highlights the importance of support policies, pedagogical monitoring and logistical strategies adapted to local realities. The PARFOR Equity proposal introduces an important qualitative change in teacher training policies by recognizing that the democratization of access to university cannot occur in a homogeneous way, but must consider cultural, territorial, linguistic and identity differences present in Brazilian society. In this sense, the program broadens the understanding of equity by incorporating demands historically made invisible by traditional educational policies.

By articulating national teacher training policies with regional demands, the programs demonstrate that the interiorization of higher education can effectively contribute to the democratization of teacher training. Among the impacts observed are the increase in the number of qualified teachers in strategic municipalities, the appreciation of cultural and linguistic diversity in basic education, the consolidation of inclusive and intercultural pedagogical practices, and the strengthening of local education networks. Such results reinforce the social function of UFMA as a mediator between public policies and historically disadvantaged educational contexts, creating conditions for teacher training to achieve greater equity.

The research also allowed us to understand that the internalization promoted by PARFOR and PARFOR Equity does not only represent the physical displacement of the university to the interior, but constitutes a political and social movement to expand the right to higher education in historically marginalized regions. This process strengthens the permanence of qualified professionals in the municipalities themselves and favors pedagogical practices that are more contextualized to local realities.

However, despite the advances, the challenges remain significant. Regional inequality still limits access in more remote municipalities, the infrastructure of the hubs and access to connectivity continue to be important obstacles, and there is a need for continuous public policies that guarantee the financial and pedagogical stability of the program. PARFOR Equity is still in its first years of implementation, and its consolidation will depend on the maintenance of follow-up strategies, training of trainers and inter-institutional articulation.

In addition, the survey revealed that many participating teachers face difficulties related to extensive travel, precarious roads, limitations in access to digital connectivity, absence or insufficiency of printing of pedagogical notebooks and the complex articulation between teaching work, intensive academic training on weekends and vacation periods, as well as family

and community responsibilities. Such conditions show that the democratization of teacher training cannot be understood only as a formal expansion of vacancies or territorial expansion of the university offer, but requires structuring policies capable of guaranteeing objective conditions of permanence, pedagogical support, access to teaching materials, digital inclusion and training quality, especially in contexts marked by regional inequalities and historical socioeconomic vulnerabilities.

Another important aspect identified throughout the investigation refers to the existing tensions between quantitative expansion and quality of training. Although the programs have significantly expanded access to licentiate degrees, challenges persist related to continuous funding, maintenance of the infrastructure of the centers, training of guiding teachers, and the administrative sustainability of the actions developed. The dependence on federal resources and the oscillations of national education policies can compromise the continuity of fundamental initiatives for states historically marked by educational inequalities, such as Maranhão.

The historical analysis developed throughout this research demonstrated that teacher training in Maranhão was, for decades, marked by the concentration of training institutions in large urban centers, by the scarcity of higher education courses and by the limited presence of the State in inland regions. In this context, PARFOR and PARFOR Equity assume strategic importance by tensioning historical structures of educational exclusion, bringing the public university closer to the social and cultural realities of the municipalities of Maranhão. Such a movement contributes to reducing regional asymmetries and strengthening basic education in territories that have historically remained on the margins of higher education policies.

PARFOR and PARFOR Equity demonstrate that structured teacher training policies can effectively contribute to the democratization of higher education and to the valorization of teaching in Maranhão. Experience indicates that, even in contexts of high social vulnerability, it is possible to offer quality degree courses, reduce historical inequalities and serve historically marginalized groups. The continuity and expansion of programs such as these are fundamental to consolidate the advances achieved and create perspectives for sustainable educational transformation. The results analyzed allow us to conclude that educational management plays a central social role in the effectiveness of these policies, since the implementation of the programs depends on permanent institutional articulations between universities, CAPES, municipal and state departments of education, pedagogical coordination and local communities.

The challenges of teacher training in Brazil and Maranhão remain, the results obtained point to promising paths, showing that equity and inclusion policies have real potential to positively impact basic education and the quality of teaching in the state and in the country.

From an interpretative point of view, the research shows that PARFOR and PARFOR Equity cannot be understood only as higher education programs, but as instruments to confront the social and educational inequalities historically produced in the Brazilian territory. By promoting access to public universities, valuing cultural identities and strengthening local education networks, these policies reaffirm education as a social right and as a concrete possibility for transforming regional realities.

Finally, it is concluded that the consolidation of teacher training policies committed to equity requires institutional continuity, strengthening of public funding and recognition of the sociocultural specificities of the different Brazilian territories. In the case of Maranhão, marked by deep historical inequalities, the strengthening of PARFOR and PARFOR Equity represents an important possibility for expanding educational justice, valuing teaching, and building a socially just, referenced, democratic, and inclusive public education.

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REINVENTION IN TIMES OF CRISIS: BRAZILIAN ENTREPRENEURSHIP BOOSTED BY THE COVID-19 PANDEMIC

REINVENÇÃO EM TEMPOS DE CRISE: O EMPREENDEDORISMO BRASILEIRO IMPULSIONADO PELA PANDEMIA DO COVID-19

REINVENTARSE EN TIEMPOS DE CRISIS: EL EMPRENDIMIENTO BRASILEÑO IMPULSADO POR LA PANDEMIA DE COVID-19



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ABSTRACT

Considering the relevance of entrepreneurship to the economic and social development of the country, in different sectors of activity, this study sought to examine, through a literature review, how the COVID-19 pandemic influenced the emergence of new entrepreneurs in Brazil. Furthermore, it aimed to identify the segments that stood out most during this period and the main challenges faced by new entrepreneurs. The justification for this research is based on the importance of understanding the role of entrepreneurship in crisis contexts, especially in the face of adverse scenarios that demand innovation, resilience, and adaptation. The research, of a qualitative and descriptive nature, was structured through an integrative review of scientific production published between 2020 and 2024. The content analysis of the studies sought to identify, select, evaluate, and synthesize the evidence on the growth of entrepreneurship in Brazil impacted by the COVID-19 pandemic. The results indicated that the pandemic acted as an accelerator for the emergence of new entrepreneurs in Brazil, driven mainly by income loss, unemployment, and the need to adapt to the digital market. It was concluded that, despite the difficulties imposed by the health crisis, the pandemic context fostered both necessity-driven and opportunity-driven entrepreneurship, strengthening innovation and reinvention in small businesses.

Keywords: Entrepreneurship. Covid-19. Economic Crisis. Innovation.

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RESUMO

Considerando a relevância do empreendedorismo para o desenvolvimento econômico e social do país, em diferentes setores de atividade, o presente estudo buscou examinar, por meio de revisão de literatura, como a pandemia do COVID-19 influenciou no surgimento de novos empreendedores no Brasil. Além disso, procurou-se identificar os segmentos que mais se destacaram nesse período e os principais desafios enfrentados pelos novos empreendedores. A justificativa desta pesquisa fundamenta-se na importância de compreender o papel do empreendedorismo em contextos de crise, especialmente diante de cenários adversos que exigem inovação, resiliência e adaptação. A pesquisa, de natureza qualitativa e caráter descritivo, foi estruturada por meio de uma revisão integrativa da produção científica publicada entre os anos de 2020 a 2024. A análise do conteúdo dos estudos buscou identificar, selecionar, avaliar e sintetizar as evidências sobre o crescimento do empreendedorismo no Brasil impactado pela pandemia do COVID-19. Os resultados indicaram que a pandemia atuou como aceleradora do surgimento de novos empreendedores no Brasil, impulsionados principalmente pela perda de renda, desemprego e pela necessidade de adaptação ao mercado digital. Concluiu-se que, apesar das dificuldades impostas pela crise sanitária, o contexto pandêmico fomentou tanto o empreendedorismo por necessidade quanto por oportunidade, fortalecendo a inovação e a reinvenção dos pequenos negócios.

Palavras-chave: Empreendedorismo. Covid-19. Crise Econômica. Inovação

RESUMEN

Considerando la relevancia del emprendimiento para el desarrollo económico y social del país, en diferentes sectores de actividad, este estudio buscó examinar, a través de una revisión de la literatura, cómo la pandemia de COVID-19 influyó en el surgimiento de nuevos emprendedores en Brasil. Además, buscó identificar los segmentos que más destacaron durante este período y los principales desafíos que enfrentaron los nuevos emprendedores. La justificación de esta investigación se basa en la importancia de comprender el rol del emprendimiento en contextos de crisis, especialmente ante escenarios adversos que exigen innovación, resiliencia y adaptación. La investigación, de naturaleza cualitativa y descriptiva, se estructuró a través de una revisión integradora de la producción científica publicada entre 2020 y 2024. El análisis de contenido de los estudios buscó identificar, seleccionar, evaluar y sintetizar la evidencia sobre el crecimiento del emprendimiento en Brasil impactado por la pandemia de COVID-19. Los resultados indicaron que la pandemia actuó como un acelerador para el surgimiento de nuevos emprendedores en Brasil, impulsado principalmente por la pérdida de ingresos, el desempleo y la necesidad de adaptarse al mercado digital. Se concluyó que, a pesar de las dificultades impuestas por la crisis sanitaria, el contexto pandémico impulsó tanto el emprendimiento por necesidad como el impulsado por la oportunidad, fortaleciendo la innovación y la reinvención en las pequeñas empresas.

Palabras clave: Emprendimiento. Covid-19. Crisis Económica. Innovación.

1 INTRODUCTION

In view of the transformations that have occurred in the market, mainly due to technological innovations and the globalization process, entrepreneurship has been consolidated as one of the main vectors of economic and social development of a country. This is because entrepreneurship stands out for its contribution to the generation of employment and income, as well as for the introduction of innovations capable of boosting and expanding the competitiveness of markets.

In the Brazilian context, characterized by high levels of social inequality and economic instability, entrepreneurial activity takes on even greater relevance. In many cases, entrepreneurship is configured as an alternative for people who face limitations in the formal labor market, sometimes representing the only possibility of generating income and subsistence.

This reality has become especially evident in times of crisis, such as the one experienced during the COVID-19 pandemic. Officially declared by the World Health Organization (WHO) in March 2020, the pandemic has forcefully exposed the fragility of the Brazilian economy (Gullo, 2020). The social isolation measures adopted to contain the spread of the virus resulted in the closure of numerous establishments and significant reductions in the revenue of micro, small and medium-sized companies. As a result, many formal workers were laid off or had their incomes significantly reduced, intensifying the search for entrepreneurial alternatives as a form of economic autonomy and survival.

In this challenging context, entrepreneurship has emerged as an alternative for economic survival. According to Gullo (2020), even with signs of possible economic recovery in early 2020, the impacts of the pandemic were profound and directly affected the income, consumption, and sustainability of numerous businesses. a

It is important to consider that the context of the COVID-19 pandemic presented a dual scenario where, on the one hand, companies closed their businesses due to the drop in demand and the inability to compete in the scenario that was presented (Nogueira; Moreira, 2023) and, on the other hand, other enterprises emerged adapting to the new reality and the new needs that emerged (Saleme; Oliveira, 2022). se

Data from the *Global Entrepreneurship Monitor Brazil Report* (GEM, 2020) show that about 53% of the Brazilian adult population showed intention to start a business in the three years following the pandemic, equivalent to approximately 50 million people. This number represented an increase of 22.5 percentage points compared to the previous year. The same survey pointed out that 32.2% of these people made this decision due to the direct influence of

the pandemic, both due to the loss of employment and the need to seek a new source of income (GEM, 2020).

Based on this perspective and the scenario imposed by the COVID-19 pandemic, the following problem arises: How did the Covid-19 pandemic influence the emergence of new entrepreneurs in Brazil, as addressed in the literature? From this question, we sought to reflect on the main elements that led people to undertake in the midst of the crisis and what lessons could be extracted from this period.

The justification for this study lies in the importance of understanding entrepreneurship as a social and economic phenomenon, especially when it arises as a response to emergencies. By investigating the factors that drove entrepreneurial behavior during the pandemic, the research seeks to contribute to the understanding of how adverse contexts can stimulate innovation, creativity, and the development of new strategies for income generation and business sustainability.

The object of study is individuals who started entrepreneurship during the COVID-19 pandemic, motivated by need, opportunity or a combination of these. These new entrepreneurs represent a significant portion of the population that reacted to the changes imposed by the crisis with creativity, resilience, and action.

It should be noted that this study was carried out through an integrative review of the scientific production published between the years 2020 and 2024. The collection of the material was carried out in the Google Scholar and CAPES Journal databases, considering articles in Portuguese that addressed, in the abstract, the emergence of new entrepreneurs or enterprises during the Covid-19 pandemic.

Thus, the general objective of the present study was to examine, through a literature review, how the COVID-19 pandemic influenced the emergence of new entrepreneurs in Brazil. Specifically, it sought to analyze the impact of the pandemic on the increase in the number of entrepreneurs in Brazil, based on articles selected in the time interval - 2020 to 2024 - and to identify the reasons that led to the creation of ventures during the COVID-19 pandemic.

2 THEORETICAL FOUNDATION

In this topic, the concepts of entrepreneurship, the economic impacts of the COVID-19 pandemic, the role of entrepreneurship as an agent of social and economic transformation, and the way in which this phenomenon has intensified in the midst of the health crisis were addressed. These discussions offered a basis for a better understanding of the relationship between the context of crisis and the emergence of new enterprises in Brazil.

2.1 ENTREPRENEURSHIP AND ITS IMPACT ON THE COUNTRY'S ECONOMIC DEVELOPMENT

According to Schumpeter (1985), economic development does not occur in a linear way, but through a "process of industrial mutation" that continuously transforms the economic structure, replacing the old with the new. This movement, called creative destruction, is driven by the figure of the Schumpeterian entrepreneur, responsible for carrying out new productive combinations capable of generating innovation (Schumpeter, 1985 *apud* Martes, 2010).

Also according to , by introducing new products, methods, markets or forms of organization, the entrepreneur acts as a central agent of structural changes, triggering cycles of renewal that drive economic growth. This Schumpeter (1985) *apud* Martes, 2010) process is considered essential for the economic and social development of a country, as it drives the continuous renewal of economic structures.

In a complementary way, Almeida, Valadares and Sediya (2017) state that entrepreneurship acts as a "development diffusion mechanism", contributing to productive diversification and to the absorption of labor in less industrialized regions. On the other hand, Ferreira, Loiola and Gondim (2020) consider that , for entrepreneurship to effectively contribute to economic growth, it is necessary to invest in training and technical support for entrepreneurs, favoring the transition from subsistence initiatives to structured enterprises. Go

Ferreira, Loiola, and Gondim (2020) also highlight the role of universities, incubators, and local public policies in building entrepreneurial ecosystems capable of sustaining regional competitiveness. This view is convergent with the recommendations of the *Global Entrepreneurship Monitor* (GEM, 2024), which highlight the need to strengthen innovation support mechanisms, bringing science, technology, and business closer together.

The same GEM survey dated 2022 already warned of the structural limitations that hinder the full conversion of entrepreneurial potential into sustainable economic development (GEM BRASIL, 2022). The Brazilian National Entrepreneurship Context Index (NECI) reached 3.6 points, a value considered intermediate, reflecting deficiencies in areas such as basic education, access to credit, and investments in research and development (GEM BRASIL, 2024).

The experts' recommendations converge on the need for public policies that promote debureaucratization, expansion of financing lines, and strengthening entrepreneurial education (GEM BRASIL, 2022). This diagnosis complements the evidence of Almeida, Valadares and Sediya (2017), according to which the positive impact of entrepreneurship on GDP is conditioned by the quality of institutions, human capital and regional infrastructure. a a o

As a way to complement the entrepreneurship scenario in Brazil, GEM data (2023) show an advance in formalization and the growing importance of "solo entrepreneurs", who represent a significant portion of the autonomous workforce. Although these entrepreneurs contribute to increased income and economic inclusion, they often face difficulties in growing or employing other workers, which limits the sector's multiplier potential (GEM BRASIL, 2023). Thus, the contemporary challenge is to transform the entrepreneurial base into an engine of innovation, productivity, and scale.

Also as a way to characterize this scenario, it is important to talk about the role of entrepreneurship as a vector of technological innovation and digitalization. The GEM (2024) presents positive data in relation to this vector: 90% of Brazilian entrepreneurs use digital technologies in their businesses and about 800 thousand new ventures have a national impact, while approximately 130 thousand already reach international reach. This demonstrates that Brazilian entrepreneurship has become more connected and competitive, contributing to technological diffusion and increased productivity.

Lima, Santos and Montebello (2025), analyzed the entrepreneurial scenario during the years 2012 to 2022 and highlight that the development of entrepreneurship in Brazil is strongly conditioned by institutional factors, especially by government policies. According to the authors, the extensive bureaucracy and the complex tax burden raise costs, hinder formalization and reduce the competitiveness of new businesses, directly limiting their ability to generate economic growth.

In addition, the results show that Brazilian entrepreneurship reflects structural inequalities: low-income individuals tend to undertake out of necessity, while higher income and higher education groups have greater stability and continuity of enterprises, revealing that the social impact of entrepreneurship is still marked by disparities in gender, income and education (Lima; Santos; Montebello, 2025).

From the data presented, a positive scenario can be seen where Brazilian entrepreneurship has been evolving in quantity and quality, presenting digital insertion, greater female and youth presence and a change in motivational profile. This trajectory reflects a maturing entrepreneurial ecosystem and a significant potential to boost the country's economic development. However, structural bottlenecks persist, such as education, government policies, infrastructure, credit, and research, which limit the conversion of this potential into sustainable productivity.

2.1.1 Entrepreneurship by necessity and opportunity

Entrepreneurship can arise from different motivations, and for Barros and Pereira (2008), it is closely related to factors such as the unemployment rate and economic growth. The authors point out that these variables have an inverse correlation, that is, when unemployment increases, the tendency is for more people to seek entrepreneurship as an alternative to overcome the lack of opportunities in the labor market.

According to Bandeira and Silva (2023), entrepreneurship by necessity occurs when the individual starts a business due to lack of income options, usually in situations of economic crisis and absence of formal work alternatives. In this case, it is an immediate response to financial difficulties, without structured planning. On the other hand, entrepreneurship by opportunity occurs when the individual identifies a business opportunity and has the skills, strategic perception and long-term vision to exploit it, being more common in developed economies, in which there is greater stability and investment capacity (Bandeira; Silva, 2023).

This distinction (opportunity x need) is also reinforced by studies that show that entrepreneurs out of necessity, in general, start their activities in an improvised way and motivated by the adverse context, acting without a minimum business structure and only to remain economically active (Silva; Istoé; Silva, 2020). Although there are successful cases, Brum (2003) *apud* Bandeira e Silva (2023) points out that entrepreneurship out of necessity should not be understood as a viable or accessible solution for everyone, since its origin is often associated with the lack of real job and income opportunities, limiting its potential for growth and sustainability.

On the other hand, entrepreneurship by opportunity occurs when the entrepreneur identifies a specific need or desire in society and, based on this, creates innovative solutions (Marques, 2022). This type of entrepreneurship has a significant impact on the economic growth of a country, as the entrepreneurs who adopt it, usually more qualified, develop businesses based on innovations and new technologies, which often have great potential for sustainable growth (Degen, 2008).

This statement by Marques (2022) and Degen (2008) is complemented by Bandeira and Silva (2023) when the latter state that entrepreneurship by opportunity occurs when the individual identifies a concrete business opportunity and decides to explore it strategically, based on skills, knowledge, and long-term vision. This motivation is more common in developed economies and is associated with more structured businesses, with greater potential for innovation.

Rocha (2014) reinforces this distinction by demonstrating that countries with a higher proportion of entrepreneurs by opportunity have higher levels of economic and social development. The author uses the Opportunity/Need Ratio (RON) as an indicator and identifies a positive correlation between RON and the Human Development Index (HDI), showing that entrepreneurship by opportunity contributes more strongly to development than entrepreneurship by necessity (Rocha, 2014). In his analysis, entrepreneurship out of necessity appears predominantly in countries with worse economic conditions, while entrepreneurship out of necessity tends to grow in more structured environments, with greater stability, capacity for innovation, and better working conditions (Rocha, 2014).

Silva, Furtado and Zanini (2015), analyzing the GEM time series between 2001 and 2013, observed a growing trend of entrepreneurship by opportunity and a reduction in the relative participation of entrepreneurship by necessity in Brazil. According to the authors, this change indicates that the country has gradually moved towards an entrepreneurial profile more aligned with planned initiatives, with greater potential for innovation, productivity, and economic impact (Silva; Furtado; Zanini, 2015).

This theoretical differentiation is also evidenced by the empirical data from the *Global Entrepreneurship Monitor*, which analyzes the evolution of these motivations in Brazil over the last few years of 2021, 2022, 2023, and 2024. In the 2021 report, GEM revealed that the entrepreneurial landscape was remarkably complex, being shaped by both need and opportunity. The study revealed that, despite a slight drop compared to the previous year, survival motivation was still intense, with a significant portion of nascent entrepreneurs, almost 8 out of 10 (79.2%), citing the search for "making a living because jobs are scarce" as a driver to start the business (GEM, 2021).

However, this motivation coexists with high aspirations linked to opportunity: the overwhelming majority of nascent entrepreneurs, for example, were driven by the desire to "make a difference in the world", while more than half aim to "build great wealth or a very high income". This intentionality is proven in the aspirational aspect, since "having one's own business" has been consolidated as the main professional dream for more than 60% of nascent entrepreneurs, and is even a goal cited by almost half (45%) of those who have not yet started any entrepreneurial activity (GEM, 2021).

In 2022, motivation by necessity continued to be prevalent in the entrepreneurial population. Data from GEM (2022) show that, for early-stage entrepreneurs (nascent and new), the search for "making a living due to the scarcity of jobs" was the main reason, being cited by just over 80% of them. This data highlighted the persistence of the function of entrepreneurship

as a refuge or alternative for the adult population in the face of the difficulties of the formal labor market (GEM, 2022).

The year 2023 marked an important change in the balance of these motivations. The GEM (2023) recorded a sharp drop in mention of need, with the option "making a living because jobs are scarce" falling to 74.1% among early entrepreneurs. For the first time in the time series, the motivation "to make a difference in the world" reached the best position in the reasons to undertake, which was interpreted by the researchers as an indication of improvement in the quality of entrepreneurship in the country. In addition, financial ambition remained robust, with 66.1% of initial entrepreneurs citing "building great wealth or a very high income" (GEM, 2023).

ranking

In 2024, the scenario once again demonstrated the complex interaction between the two vectors. According to GEM (2024), motivation for opportunity solidified his leadership, with "making a difference in the world" being the most cited (74.6%). However, the need remained at high levels, with 73.9% of the initial entrepreneurs citing "making a living because jobs are scarce", reflecting the economic instability. What stood out the most in 2024 was the record proportion of people who answered "to build great wealth or a very high income" (69.3%). This convergence of data reaffirms the nature of Brazilian entrepreneurship as a field where the drive for survival coexists and often merges with ambition and aspiration for impact and substantial financial growth (GEM, 2024).

2.2 ECONOMIC AND SOCIAL SCENARIO: THE COVID-19 PANDEMIC

The health crisis hit the country at a time of slowdown, causing a sharp retraction of productive activities. The Gross Domestic Product (GDP), the unemployment rate, and price indices showed intense instability between 2020 and 2021 (Miguel, 2021). Also according to Miguel (2021), the irregular behavior of these indicators reflects the direct impact of social isolation measures and highlights the vulnerability of national economic policies to external shocks. , to

In a complementary analysis, Paula, Vaz, and Machado (2023) state that, when the pandemic took hold, the economy was already in a scenario of stagnation and precariousness of the labor market, marked by high informality and income inequality. The authors note that economic policy, since 2015, had been guided by a liberal and fiscally restrictive cut, focused on the Spending Ceiling and austerity measures. This context significantly limited the State's capacity to respond to the health crisis, intensifying a process of preexisting social and

economic crisis, characterized by the combination of high unemployment, informality, and structural inequality (Garbe, 2021).

It can be observed, based on the data presented above, that the health crisis manifested a profoundly unequal character, affecting historically vulnerable social groups more severely, women, young people, blacks, and informal workers, resulting in greater loss of income and exclusion from the labor market (IPEA, 2022). Also according to the Institute of Applied Economic Research (IPEA, 2022), the most affected sectors were those that depend on face-to-face contact (commerce, personal services, and tourism), while activities with the possibility of remote work showed less retraction. These data from IPEA (2022) confirm the deepening of structural inequalities and the reinforcement of social and racial segmentation in the Brazilian labor market.

Garbe (2021) also points out that the crisis revealed the insufficiency of public policies for social protection and highlighted the need to rethink the role of the State as an inducer of development and guarantee of well-being. At the same time, Aguiar (2024), when exploring COVID-19 in a context of socioeconomic inequalities, suggests that the populations most affected by the disease are also the most susceptible to precariousness and job loss, deepening social disparities in a scenario of economic downturn and growing unemployment.

To complement this scenario, Mazuqueli (2022) portrays that the unemployment rate underwent significant changes after the emergence of the new coronavirus, registering a strong upward trend. The author uses data from the IBGE, which indicate that, in the first quarter of 2021, the number of unemployed people reached 14.805 million, the highest level since the beginning of the time series of the Continuous National Household Sample Survey (PNAD-C).

While many countries quickly adopted policies to expand public spending to contain the social and productive impacts of the crisis, the Brazilian government initially maintained a hesitant stance. The Executive's priority continued to be the maintenance of fiscal adjustment, even in the face of the worsening economic and humanitarian scenario (Paula; Vaz; Machado, 2023).

Within this more conservative context, the creation of the Emergency Aid ended up representing a temporary break with this logic. Paula, Vaz, and Machado (2023) highlight that this measure did not arise from a government initiative, but rather from strong pressure from the National Congress and civil society, which reacted to the lack of effective responses to protect the most vulnerable population and face the sharp drop in income.

In addition to the social impact, the crisis caused serious damage to the productive sector, especially to Micro and Small Enterprises (MSE's). Nogueira and Moreira (2023) point

to the destruction of the capital stock of these companies as one of the most serious consequences of the pandemic. According to the authors, by June 2020, the country had lost billions in fixed capital, reflecting the closure of more than 716 thousand companies, the vast majority of which are small. This loss of productive capacity has compromised the potential for long-term employment and income generation, exposing the fragility of MSEs in the face of systemic crises (Nogueira; Moreira, 2023).

The analysis of the different studies reveals a point of convergence: the pandemic has deepened structural vulnerabilities and reinforced the importance of the State in the coordination of economic and social policies. In addition, the pandemic crisis has intensified social inequalities, significantly affecting the dynamism and conditions for entrepreneurial action in Brazil.

2.3 ENTREPRENEURSHIP IN TIMES OF CRISIS: THE COVID-19 PANDEMIC

As seen in the previous topics, entrepreneurship has been consolidated as an essential element for economic and social development, especially in contexts of instability. According to Fialho *et al.* (2018), periods of crisis, although challenging, also work as catalysts for innovation, encouraging individuals to seek new opportunities and creative ways to generate income.

In this sense, economic crises present themselves as fertile scenarios for the emergence of new entrepreneurs, driven both by the need for survival and by the desire for autonomy and personal fulfillment. This understanding is reflected in the data from the Covid-19 pandemic: during this period, Brazil recorded records in the opening of new micro-enterprises. As an example, between February and September 2020, there were more than 1.15 million new formalizations of MEI's, driven by the economic crisis (Agência Brasil, 2020).

For Nassif, Corrêa and Rossetto (2020), the pandemic required entrepreneurs to have a deep capacity for adaptation, since the health context imposed sudden ruptures in traditional ways of managing business. According to the authors, this scenario forced many entrepreneurs to develop not only creativity, but above all resilience to deal with uncertainties, restrictions, and the constant need for reinvention.

This view dialogues with what Schumpeter (1985, *apud* Martes, 2010) already defended: the entrepreneur is an agent of transformation, capable of converting adverse moments into opportunities for innovation and economic growth. This discourse of reinvention was confirmed again in the pandemic: the total rate of entrepreneurship in Brazil fell by 18.33% in 2020, according to the Brazilian Micro and Small Business Support Service (SEBRAE), but this decline was strongly fueled by the departure of established entrepreneurs (over 3.5 years old), while many new entrepreneurs entered the market, out of necessity (SEBRAE, 2020). a

Oliveira and Ferreira (2023) highlight that the emergence of the virus and social isolation measures caused an unprecedented global crisis, forcing companies and entrepreneurs to rethink their operating strategies. In a scenario of paralysis of economic activities, many entrepreneurs needed to adopt innovative and quickly adapted practices to ensure the survival of their businesses.

In line with this perspective, Lima, Santos, and Montebello (2025) show that this adaptation process did not only occur at the behavioral level, but was also reflected in national statistics: during the years 2020, 2021, and 2022 there was a significant increase in entrepreneurship out of necessity, driven by the increase in unemployment and the reduction of formal job opportunities, leading a large part of the population to undertake as an alternative for economic survival.

In this scenario, Ponsoni and Teixeira (2024) reinforce that micro and small enterprises (MSEs), responsible for a large part of job creation in Brazil, were the most affected, given their weaker structure and lower capacity for financial resistance. However, the strengthening of the entrepreneurial spirit and the emergence of new businesses were observed, especially focused on innovation and customer loyalty (Ponsoni; Teixeira, 2024).

This phenomenon of "bottom-up" renewal is also corroborated by data on business openings: according to CNN Brasil, between 2020 and 2022 the number of new companies in the country grew by 25.3%, compared to the previous three years (CNN Brasil, 2022). To a large extent, these new businesses are micro enterprises (94% according to the report), which fits well into the profile of emerging businesses by necessity and creativity. In addition, GEM data (2021) show that about 50% of entrepreneurs, at all stages, perceived new opportunities resulting from the pandemic (GEM, 2021).

Despite the positive scenario, which was demonstrated above, by data from CNN Brasil (2022) and GEM (2021), the health crisis was associated with the closure of many enterprises: 46.2% of the Brazilian population discontinued some business due to the pandemic between 2020 and 2021. In addition, the context of restrictions has led many entrepreneurs to adapt their internal processes, with almost half of nascent entrepreneurs adopting or accelerating digital technologies in response to the pandemic, while among new and established entrepreneurs this percentage was around a third (GEM, 2021).

In addition, Lima *et al.* (2024) address the concept of "*effectuation*", which is a theory about a strategy for coping with crises, in which the entrepreneur, in the face of uncertainty, uses the available resources in a creative and flexible way. This approach values practical action

and the ability to improvise, which proved crucial during the pandemic, when responses needed to be quick and adapted to resource scarcity.

The pandemic has also revealed the importance of social and academic entrepreneurship. Prytoluk and Boll (2023), when analyzing the case of the Federal University of Rio Grande do Sul, demonstrated how higher education institutions began to develop entrepreneurial actions aimed at innovation and extension, contributing to society in a time of crisis. This performance reflects the role of entrepreneurship as a tool for social transformation, going beyond the creation of businesses and incorporating collective responsibility. This social impulse, in fact, is mirrored in the new formalizations of MEI's motivated by necessity, as reported by Agência Brasil (2020), which highlights the crisis, but also the capacity for individual reinvention with collective impact.

According to the data presented, entrepreneurship has become an important tool to face the challenges of the health crisis, driven by digitalization and the use of technologies. The expansion of digital and informal entrepreneurship demonstrates the capacity of Brazilians to reinvent themselves in the face of the economic and social restrictions imposed by the period (Araújo; Alves; Silva, 2021).

Finally, Backes *et al.* (2020) point out that the pandemic not only changed business dynamics, but also redefined strategic management models, imposing the need for new organizational and planning practices in contexts of uncertainty. Organizations that were able to react with agility and innovative vision were the ones that best adapted, confirming that entrepreneurship continues to be one of the main drivers of transformation and overcoming in times of crisis (Backes *et al.*, 2020).

The data presented above show entrepreneurship as an important mechanism for economic recovery, being able to promote creative and sustainable solutions even in periods of crisis. It manifests as an active response to adversity, turning uncertainty into opportunity and driving development through creativity, innovation, and resilience.

3 METHODOLOGY

This research used a qualitative approach, with a descriptive nature and carried out from a bibliographic research, specifically, by the method of integrative literature review. The research is characterized as qualitative because it seeks to understand the meanings, interpretations and perceptions present in studies on the impact of the pandemic on entrepreneurship, analyzing the phenomena in their context. At the same time, it has a

descriptive character because it aims to describe and characterize this growth, identifying segments, challenges and trends pointed out in the literature.

Lima and Mito (2007) define bibliographic research as a methodological procedure that enables researchers to search for solutions to their research problem. The authors emphasize that this type of research implies an ordered set of procedures for searching for solutions, attentive to the object of study, and that, therefore, it cannot be random.

Among the types of review, the integrative review is the most comprehensive, which represents an advantage because it allows the simultaneous inclusion of experimental and quasi-experimental studies, offering a broader view of the researched theme, in addition to allowing the gathering of information from both theoretical and empirical productions, which contributes to a more complete and in-depth understanding of the phenomenon studied (Mendes, Silveira; Galvão, 2008). This approach contributes to defining concepts, reviewing theories, identifying evidence, and analyzing possible methodological gaps in existing productions (Souza, Silva; Carvalho, 2010).

This methodology was chosen because it allows the identification of evidence, the mapping of trends and the critical analysis of the main results presented in the literature. The focus in question was studies that address the COVID-19 pandemic and its impact on the emergence of new entrepreneurs, considering articles published on the Google Scholar and Capes Journal platforms, in the period from 2020 to 2024.

3.1 DATA COLLECTION, PROCESSING AND ANALYSIS

The present study followed the phases proposed by Souza, Silva and Carvalho (2010), which guided the methodological conduct of the integrative literature review. These steps ensure a systematic and rigorous process, enabling the synthesis of available knowledge. According to the authors mentioned above, this form of review is composed of six phases, namely: elaboration of the guiding question, search in the literature, data collection, analysis of the included studies, discussion of the results and presentation of the review.

The first phase corresponds to the elaboration of the guiding question, considered one of the crucial stages for the development of the study. It is at this moment that the question-problem of the research is defined, in a clear and specific way, outlining the objects of study and the information that is sought to be obtained throughout the investigation. Following the proposed phase, the research question that guided this Integrative Review was formulated: "What is the impact of the COVID-19 pandemic on the increase in the number of new entrepreneurs in Brazil and what factors motivated this growth?"

The second phase consists of searching the literature, a stage directly connected to the previous one. This phase involves prospecting in digital or physical databases, looking for content relevant to the focus of the study. It is imperative to address all the criteria for selecting and excluding the results obtained, ensuring the necessary specification to attest to the reliability and reliability of the research carried out (Souza; Silva; Carvalho, 2010).

In carrying out the literature search, the Google Scholar and CAPES Journals databases were used, prioritizing articles published in Portuguese, in the period from 2020 to 2024, to ensure the updating of the data in relation to the proposed theme.

On Google Scholar, the search was carried out through the advanced search tool. The inclusion criteria were: containing the words "Entrepreneurship" and "COVID-19" in the title; address in the summary the focus on new entrepreneurs or new ventures that emerged during the pandemic; be in Portuguese and be an article published in scientific journals, annals of events or symposia. For this research, the following coordinate was used: *allintitle:* entrepreneurship new OR entrepreneurs OR entrepreneurship "covid 19" 2020-2024, obtaining 90 results, of which 8 articles were selected for meeting the inclusion criteria.

In the CAPES Periodicals database, the coordinate was used: "new entrepreneurs" "covid-19" 2020-2024, obtaining 2 results, both selected according to the defined criteria, namely: addressing in the abstract the focus on new entrepreneurs or new ventures during the pandemic and being in Portuguese.

The third phase is dedicated to data collection, whose main objective is to accurately select all the information necessary for the study. This includes the identification of the subjects involved, the methodology addressed, the size of the sample obtained, the method of analysis employed and the concepts used that served as a basis for the research. s e

In this sense, the subjects involved correspond to the studies analyzed, which represent scientific productions on entrepreneurship in the context of the COVID-19 pandemic. The methodology adopted at this stage followed the design proposed by the integrative review, with defined inclusion and exclusion criteria that ensured the rigor of the selection. The size of the sample obtained was determined after screening the results found in the databases. A total of 92 articles were found, after applying the initial filters in the selected databases. For the final selection, inclusion and exclusion criteria were adopted. In Table 1, it is possible to see the inclusion and exclusion criteria of the articles found.

Table 1
Criteria for selection of Articles

Inclusion	Exclusion
Works that have in their title the context of the COVID-19 pandemic	Articles that do not deal with Brazilian entrepreneurs
Articles that address the topic of new entrepreneurs in the summary	Summaries that don't explicitly mention a focus on new entrepreneurs
Publications in Portuguese	Works from non-scientific sources or in another language
Availability in scientific journals, conference proceedings or symposia	Duplicate articles

Source: Prepared by the authors, 2025.

Table 2 shows the selected articles, containing information such as the title, the name of the authors, the year of publication, and their source.

Table 2
Selected Articles

N o.	Article Title	Author(s)	Year	Source
1	Entrepreneurship in the context of covid-19: need, opportunity and solidarity	Cristiane Pereira Guimarães, Quésia Klem Horsts de Oliveira, Matheus de Souza Dimas, Társis De Marcos Corrêa	2022	Pensar acadêmico v. 20 n. 1, p. 93-105.
2	Female entrepreneurship and digital marketing in border territories during the covid-19 pandemic	Jéssica Andrade Fleitas, Dionni Benites, Álvaro Freitas Faustino-Dias, Manoela Moraes, Luisa Rhoden Rech	2024	Boletim de Conjuntura, v. 19, n. 55, p. 579–600.
3	Entrepreneurship during the covid-19 pandemic: analysis of the numbers of new microentrepreneurs in the Brazilian market in the period of 2020 and 2021	Jéssica Franciele Rodrigues Azevedo, Leandra Mariana Viana de Souza, Luiz Augusto Dias de Melo, Mara Lopes da Silva, Greyce Lara Pereira	2022	Scientific Journal of Faculdade Quirinópolis, Quirinópolis, 2022, v. 2, n. 12, p. 7-30.
4	The growth of entrepreneurship motivated by the covid-19 pandemic	Cristiane Henrique Batista, Simone Teles da Silva Costa, Dênia Aparecida de Amorim	2024	. Management, Technology and Science Journal (GETEC), 2024, v. 14, p. 77-94
5	Unemployment and entrepreneurship in the Covid-19 pandemic and its effects on Brazilian society	Katia Gobatti Calças, Mitali Daian Alves Maciel, Sebastião Ailton da Rosa Cerqueira-Adão	2022	Revista de Administração da UFSM, v. 15, p. 743–759
6	The Impact of the Covid-19 Pandemic on Entrepreneurship: a study on the perception of Entrepreneurs in the Municipality of Resende - RJ	Amanda Fagundes Soares, Gabriela Fonseca de Moura, Rayla dos Santos Oliveira Dias	2021	Symposium on Excellence in Management and Technology, SEGet 8.
7	Entrepreneurship and the fear of failure: a comparative study supported in the context of the covid-19 pandemic	Alex Ribeiro Maia Baroni, Renata de Sousa da Silva Tolentino	2024	Revista de Administração FACES Journal, v.23, n.4, p. 118-137.

8	Entrepreneurship of opportunities in digital marketing in the context of the covid-19 pandemic	Joice Darc Maranini dos Santos, Ana Carolina Nascimento dos Santos	2021	Conic Semesp, 21st Congress of Scientific Initiation, v. 12, n. 12.
9	Entrepreneurship and Covid-19: Opportunities in the Pandemic	Anderson Lopes Nascimento, Sérgio Castro Gomes.	2020	Methods and Research in Administration, v. 5, n. 2, p. 2-6
10	Trademark registration in the pandemic era: relevance in the face of increased entrepreneurship	Bárbara Giacomazzo de Carvalho	2023	Journal of Entrepreneurship and Management of Micro and Small Enterprises, v. 7, n. 03, p. 18–30

Source: Prepared by the authors, 2025.

After the selection of the articles, the next phase corresponds to the analysis of the included studies. The analysis method used consisted of reading the abstracts and subsequent critical analysis of the selected articles, in order to identify convergences and patterns in the publications. The concepts used were extracted from the included studies, serving as a theoretical basis for understanding the factors that drove the emergence of new entrepreneurs in the context of the pandemic.

The collection in the databases was carried out on May 24, 2025 and 10 articles were selected, 8 from Google Scholar and 2 from CAPES Journals. All articles were read in full and critically analyzed, with the aim of identifying the main factors that drove the emergence of new entrepreneurs in the context of the pandemic.

The analysis of the articles was carried out with the objective of answering the research question. Therefore, we sought to identify convergences and divergences between the selected studies, grouping the main factors highlighted in the analyzed articles.

From this analysis, the results of this work were structured according to the final stages proposed by Souza, Silva and Carvalho (2010). The fifth phase corresponds to the discussion of the results, at which time the studies are analyzed together to answer the research question and identify limitations and suggestions for future work. Finally, the sixth phase refers to the presentation of the integrative review, carried out in a clear and objective manner, allowing the reader to understand and evaluate the results obtained.

4 RESULTS AND DISCUSSION

In this topic, the results of the ten articles chosen in the integrative review were presented. The results sought to respond to the objective of the research, which was: To examine, through a literature review, how the COVID-19 pandemic influenced the emergence of new entrepreneurs in Brazil. Specifically, the objective was to analyze the impact of COVID-

19 on the increase in entrepreneurship in Brazil and the reasons for the creation of new ventures.

The research carried out by Guimarães *et al.* (2022) aimed to explore entrepreneurship in the context of the COVID-19 pandemic, analyzing in particular its link with unemployment, informal work and the Brazilian economic crisis. In this context, the authors point out that a large part of the population saw entrepreneurship as an instant option to obtain income, given the scarcity of government measures.

Guimarães *et al.* (2022) reveals that entrepreneurship out of necessity was in evidence during the pandemic period, since part of the population began to undertake not by identifying opportunities, but by the lack of formal work options. In addition, there was an increase in the formalization of individual microentrepreneurs (MEIs) and the emergence of the so-called solidarity entrepreneurship, characterized by creativity and community collaboration, as a response to the crisis.

Fleitas *et al.* (2024) sought to identify the relationship between women living in border territories and entrepreneurship focused on digital strategies during the period of the COVID-19 pandemic. This is a qualitative research using semi-structured interviews conducted with five entrepreneurs from Ponta Porã (MS), on the border between Brazil and Paraguay. The study highlights that these regions are characterized by very specific economic and social dynamics, influenced by their proximity to neighboring countries and the strong presence of small businesses. As the pandemic progressed, the restrictions mainly affected these small businesses, which were forced to adapt their operations to survive. *Marketing*

In this scenario, digital has emerged as a strategic tool to overcome challenges, build customer loyalty, and discover new opportunities. Fleitas *Marketing et al.* (2024) show that, for these women, digitalization is not only considered as a resource, but also a way to reposition themselves in the market, enabling greater visibility, direct communication with consumers, and expansion of commercial reach. The study demonstrates that the pandemic accelerated the adoption of digital practices, showing that digital innovation was fundamental for both the survival and growth of the businesses analyzed.

Through a literature review and descriptive research using databases of companies of the Federal Government and information from Sebrae, the authors Azevedo *et al.* (2022) aimed to identify and analyze the number of new micro and small companies opened in Brazil in 2020 and 2021, during the most critical period of the pandemic. The study was based on the observation that the pandemic caused profound changes in the economic and social scenario, increasing unemployment and making it difficult for physical businesses to operate.

The results of Azevedo *et al.* (2022) show a strong increase in the number of new companies opened, with more than 3 million in 2020 and more than 2 million in 2021, indicating an intensification of entrepreneurship during the crisis. The study also highlights that much of this growth is related to entrepreneurship out of necessity, motivated by unemployment and the urgent search for alternative sources of income. Additionally, the work highlights that, although the pandemic has imposed difficulties, it has also stimulated entrepreneurial initiatives in different sectors.

Batista, Costa and Amorim (2024) conducted a bibliographic research, with a focus on 2010, with the objective of analyzing how the pandemic boosted the growth of entrepreneurship in Brazil. The authors contextualize that the pandemic has brought accelerated changes in consumption patterns, social interactions, and economic activity. The study reveals that, despite the crisis, entrepreneurship continued to grow, driven mainly by necessity, as many people were forced to take ideas off the paper as an alternative to survival, especially in the face of rising unemployment and falling family income.

The data presented by Batista, Costa and Amorim (2024) indicate that sectors such as *e-commerce*, the pharmaceutical sector, *delivery* services, supermarkets, lunch box trade, beverages, pets, sports consulting, computer items, domestic and construction services stood out as viable alternatives due to the restrictions. The work also highlights that there was business adaptation, digitalization and resilience, indicating that many entrepreneurs took advantage of the circumstances to innovate and reinvent themselves.

In the research by Calça, Maciel and Adão (2022), carried out through quantitative, descriptive research, using the survey method - through the IBGE, GEM and Entrepreneur Portal databases - analyzes the relationship between unemployment and entrepreneurship in Brazil from 2016 to 2021, focusing on the pandemic period. Descriptive and inferential statistical analyses were performed. The results indicate that, during the pandemic, there was a 14% increase in unemployment, a 23% increase in the number of new ventures, and a significant increase in the number of active MEIs. or

Although these data indicate an increase in entrepreneurial activity during this period, Calça, Maciel, and Adão (2022) find that unemployment showed a low correlation with the start of new ventures, suggesting that other factors influenced the decision to undertake more strongly. On the other hand, the study demonstrates a link between the start of new ventures and formalization through MEI's, highlighting that many new entrepreneurs sought formal means to remain active. The study contributes by demonstrating that the Brazilian reality during

the pandemic is complex and cannot be explained only by the direct relationship between unemployment and entrepreneurship.

Soares, Moura, and Dias (2021) examined the impact of the pandemic on entrepreneurs in Resende (RJ), comparing existing businesses with those created during the crisis. The research is qualitative in nature and used semi-structured interviews applied to six participants, organized into two groups: Three entrepreneurs active before the pandemic and three who started entrepreneurship amid the restrictions imposed by the pandemic scenario.

In this environment, small businesses were the most affected, needing to adapt through new sales strategies, intensified use of social networks, and reformulation of processes. Soares, Moura and Dias (2021) highlight that the pandemic boosted the growth of entrepreneurship, especially through the MEI regime, which reached more than 10 million registrations. Among the interviewees who started their businesses during the pandemic, motivation by necessity predominated, mainly due to unemployment and reduced family income. However, cases of identification of opportunities have also emerged, especially related to the increase in demand for digital services, a *delivery*, and essential products.

The work of Baroni and Tolentino (2024) sought to investigate how the fear of failure influenced the intention to undertake in Brazil during the pandemic, using GEM data for the years 2019 and 2020, being a comparative quantitative research, using Spearman's statistical methods of correlation and Analysis of Variance (ANOVA), with the objective of finding relationships between schooling, entrepreneurial knowledge, self-confidence and fear of negative results.

Baroni and Tolentino (2024) contextualize the pandemic period characterized by severe economic instability, increased unemployment, and a social climate of uncertainty, which reinforced the perception of risk among potential entrepreneurs. The authors demonstrate that, despite this unfavorable scenario, many people remained interested in opening new businesses, especially those with higher education and familiarity with entrepreneurial practices. However, the fear of failure intensified in 2020, mainly affecting groups with lower education. The results suggest that more qualified people tend to assume behaviors aligned with entrepreneurship by opportunity, while individuals with lower education and income demonstrate characteristics closer to entrepreneurship by necessity, especially in the face of the economic difficulties caused by the crisis (Baroni; Tolentino, 2024).

Through a qualitative research based on interviews, Santos, Santos and Moraes (2021) analyzed how digital drove the emergence of a silver enterprise during the Covid-19 pandemic, taking as a case study a microenterprise based in Fernandópolis (SP). The interview was

conducted with the owner and an analysis of her documents and institutional strategies was also carried out. The authors emphasized that the pandemic has caused profound changes in consumer behavior, accelerating the expansion of e-commerce. In this scenario, many entrepreneurs have found in digital media a way to promote their products, interact with customers, and maintain their business even amid the restrictions of face-to-face activities.

Marketing Jewelry

Santos, Santos and Moraes (2021) also reveal that the microenterprise analyzed emerged precisely at the height of these transformations, relying on digital marketing practices, particularly the use of social networks, such as *Instagram* and *WhatsApp*. The founder identified a market opportunity, realizing that consumers were looking for affordable products and personalized service through digital channels. Therefore, the analyzed business is mainly characterized as a case of opportunity entrepreneurship, since it arose from the identification of consumer trends and the expansion of *online commerce*.

Nascimento and Gomes (2020) investigated the ways in which Brazilian entrepreneurs identified and used business opportunities during the pandemic, analyzing, in particular, the emergence of new ventures in the digital environment. This qualitative study used a focus group with nine participants, whose reports were examined through Similarity Analysis and Meaning Nucleus. The authors contextualized that the pandemic significantly impacted sectors such as commerce, tourism, and entertainment, leading to the closure of many businesses and a significant drop in the population's income.

At the same time, they observed profound changes in consumption habits, with a strong migration to delivery services, *online shopping* and digital communication. In this scenario, many entrepreneurs have recognized opportunities, especially through the intensive use of social media and the *internet* as their primary advertising and sales channels. The results show that the number of online store openings in Brazil increased dramatically, reaching more than one per minute in the first months of the pandemic. The focus group revealed that the participants were motivated by curiosity, the need to adapt and the gap left by the closure of physical stores (Nascimento; Gomes, 2020).

Carvalho (2022) analyzed the relationship between the growth of entrepreneurship during the COVID-19 pandemic and the significant increase in trademark registrations at the National Institute of Industrial Property (INPI). The study discusses economic and social data from this period, highlighting the increase in unemployment, the drop in family income, and the massive migration of consumers and companies to the digital environment.

The author demonstrates that 2021 was a record year in Brazil in terms of the number of new businesses, with more than four million openings, linked both to the search for alternative forms of survival and the discovery of new needs created by the pandemic. Simultaneously, there was a significant increase in trademark applications, demonstrating the desire of new entrepreneurs to strengthen their business identity and gain market share. The study points out that the growth of entrepreneurship had different motivations, on the one hand, many people resorted to entrepreneurship out of necessity, due to job loss and, on the other hand, sectors linked to *online* commerce and digital media made room for entrepreneurs by opportunity who identified promising niches (Carvalho, 2021).

4.1 MOTIVATIONS TO UNDERTAKE DURING THE COVID-19 PANDEMIC

The studies that made up the literature review highlight several factors that motivated entrepreneurship during the pandemic period. The motivations that were most mentioned were presented in Table 3.

Table 3

Motivations to Undertake in the Pandemic

Motivations for Entrepreneurship during the Pandemic	Number of studies that mentioned motivation
Unemployment and falling income	8 studies cited this factor as a motivation to start entrepreneurship during the pandemic.
Identification of new demands in the market	7 studies cited this factor as a motivation to start entrepreneurship during the pandemic.
Accelerating digitalization and the use of digital <i>Marketing</i>	7 studies cited this factor as a motivation to start entrepreneurship during the pandemic.
Search for formalization through registration as an individual microentrepreneur (MEI)	3 studies cited this factor as motivation to start entrepreneurship during the pandemic.

Source: Prepared by the authors, 2025.

Unemployment and loss of income appear as the main reason that led many people to undertake during the pandemic. Guimarães *et al.* (2022) draw attention to the direct impact of business closures, showing that, given the lack of government support, many people saw entrepreneurship as the most immediate way to survive. Azevedo *et al.* (2022) reinforce this idea by presenting data showing the opening of millions of new businesses in 2020 and 2021, showing that most people resorted to entrepreneurship out of necessity.

The perspective of Batista, Costa and Amorim (2024) follows the same line, pointing out that family income decreased rapidly and that this caused many ideas to be "taken off the paper", more out of urgency than planning. Despite this association, Calça, Maciel, and Adão (2022) bring an interesting counterpoint by showing that, statistically, unemployment and the

creation of new businesses do not have as high a correlation as one might think, suggesting that other elements also influenced this movement.

Even so, in the study by Soares, Moura, and Dias (2021), the interviewees clearly report that they resorted to entrepreneurship after losing their jobs, revealing how this phenomenon manifests itself in practice. Baroni and Tolentino (2024) complement by indicating that groups with less education suffered more from economic insecurity, which increased both the fear of failure and the dependence on entrepreneurship as an alternative income. Nascimento and Gomes (2020) and Carvalho (2022) reinforce that the closure of consolidated sectors and the sharp drop in income stimulated not only the search for new forms of work, but also the search for business models adapted to the new reality.

The pandemic not only brought difficulties, but also promoted the opening of opportunities that were strategically identified and explored by several entrepreneurs. In this sense, Guimarães *et al.* (2022) point out that the crisis generated changes in consumption that created gaps in the market, while Azevedo *et al.* (2022) show that specific sectors grew precisely because they met emerging needs, such as food, essential services, and businesses in delivery format.

Batista, Costa, and Amorim (2024) expand this discussion by bringing concrete examples of areas that have been strengthened, such as information technology, domestic services, and *online commerce*, revealing how some activities have become more viable precisely because they adapt to the context of social isolation. Other studies have helped to understand how this identification of new demands occurred in practice. Fleitas *et al.* (2024), for example, show that women in border regions observed rapid changes in the profile of consumers and adapted their businesses using new strategies to stay active.

Soares, Moura, and Dias (2021) brought reports from entrepreneurs who took advantage of the increased demand for digital services and deliveries, realizing that opportunities existed even in the midst of the crisis. In the same vein, Santos, Santos, and Moraes (2021) analyze a case in which the founder of a microenterprise noticed a greater demand for affordable products and personalized service, creating a business that was born fully aligned with new consumer expectations.

Finally, Nascimento and Gomes (2020) show that many entrepreneurs identified opportunities precisely because of the adaptation of consumers to the digital environment, revealing a scenario where demands changed quickly and, those who realized this first, were able to position themselves better.

It is a fact that the digitalization of business has been accelerated by the pandemic. Guimarães *et al.* (2022) highlight that the digital environment became practically mandatory for those who wanted to maintain some form of income. Azevedo *et al.* (2022) reinforce this by pointing out that many new businesses have emerged already structured to operate entirely *online*.

Fleitas *et al.* (2024) revealed how digital marketing has consolidated itself as a survival tool among frontier entrepreneurs, making it essential for communication, loyalty, and repositioning in the market. This movement also appears strongly in qualitative studies. Soares, Moura, and Dias (2021) reported that entrepreneurs used social networks as their main sales channel, demonstrating a quick adaptation to the new scenario. Santos, Santos, and Moraes (2021) analyzed the case of a company that was born within these practices, using *Instagram* and *WhatsApp* to create a close and personalized service.

Nascimento and Gomes (2020) reinforce that many businesses have come to exist only in the digital environment, driven by the growth of *e-commerce* and the change in consumer behavior. Carvalho (2022) complements by showing that, along with this digitalization, trademark registration increased, indicating that new entrepreneurs wanted to consolidate their presence in the *online* environment and compete more strategically.

Formalization through the MEI appears as an important path for some entrepreneurs. Guimarães *et al.* (2022) point out that regularization was a way to ensure some security and legitimacy for businesses that emerged in an improvised way. Calça, Maciel and Adão (2022) reinforced that formalization grew, especially among those who had already started some type of informal activity and sought to stabilize their situation in the market.

Soares, Moura, and Dias (2021) highlighted that the number of MEI's exceeded the 10 million mark, showing that registration became an option for many workers who sought to better structure their businesses and access basic rights.

5 FINAL CONSIDERATIONS

Based on the ten articles analyzed in the integrative review carried out, it is possible to say that the COVID-19 pandemic had an impact on the entrepreneurial scenario in Brazil. Importantly, this is a statement based on the 10 selected studies. In addition, it was observed in the studies that the pandemic ended up boosting new enterprises, especially those created out of necessity, due to the increase in unemployment and the reduction in family income. At the same time, the pandemic period also provided the emergence of new opportunities, especially in the digital environment, which has consolidated itself as an essential strategic element for the creation, adaptation, and continuity of business models.

The studies analyzed during the work showed that many Brazilians began to see entrepreneurship as an alternative to ensure their livelihood. Others had the ability to identify demands/gaps in the market, managing to innovate, even with the uncertainties of the moment. The acceleration of digitalization, the more intense use of digital and the greater search for formalization through the MEI, are examples of how entrepreneurs needed to reinvent themselves to continue operating and remain active in the market. *Marketing*

The present work has a current and specific theme, which ended up limiting the selection process of the studies that would compose the basis of articles for the integrative bibliographic review. Thus, the greatest difficulty encountered during the work was to build a theoretical framework that makes it possible to develop the research in a complete way, achieving the general objective and the specific objectives previously established. As a suggestion for future studies on the subject, the analysis of the health of these enterprises and what is their permanence rate in the current scenario. It is indicated

Finally, it is concluded that the pandemic, despite bringing challenges, also opened space for reinventions, being new ways to generate income and promote development. In this scenario, entrepreneurship stood out as a viable, resilient, and fundamental alternative for many Brazilians to rewrite their trajectories and adapt to a challenging reality.

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IMPACT OF MATERIAL PLANNING ON THE REDUCTION OF LOGISTICS COSTS IN THE MANUFACTURING INDUSTRY

IMPACTO DO PLANEJAMENTO DE MATERIAIS NA REDUÇÃO DE CUSTOS LOGÍSTICOS NA INDÚSTRIA MANUFATUREIRA

IMPACTO DE LA PLANEACIÓN DE MATERIALES EN LA REDUCCIÓN DE COSTOS LOGÍSTICOS EN LA INDUSTRIA MANUFACTURERA



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ABSTRACT

The study analyzes the impact of material planning on the reduction of logistics costs within the manufacturing industry, highlighting the strategic role of tools such as Material Requirements Planning (MRP). Using a quantitative, correlational, and cross-sectional approach applied to 32 manufacturing companies in Guanajuato, the relationship between material management, inventories, transportation, and storage was evaluated. The results showed that adequate material planning significantly contributes to reducing logistics costs, optimizing inventories, decreasing obsolescence, and improving operational coordination. Likewise, it was identified that synchronization between supply, production, and distribution promotes organizational efficiency. However, limitations still persist regarding the reduction of urgent transportation and the achievement of full logistics integration. It is concluded that material planning constitutes a strategic element for strengthening the competitiveness and resilience of manufacturing organizations.

Keywords: Material Planning. Logistics Costs. Manufacturing Industry. Inventory Management.

RESUMO

O estudo analisa o impacto do planejamento de materiais na redução de custos logísticos dentro da indústria manufatureira, destacando o papel estratégico de ferramentas como o Material Requirements Planning (MRP). Por meio de uma abordagem quantitativa, correlacional e transversal aplicada a 32 empresas manufatureiras de Guanajuato, avaliou-se a relação entre a gestão de materiais, os estoques, o transporte e o armazenamento. Os resultados evidenciaram que um planejamento adequado de materiais contribui significativamente para a redução dos custos logísticos, otimização dos estoques, diminuição da obsolescência e melhoria da coordenação operacional. Além disso, identificou-se que a sincronização entre abastecimento, produção e distribuição favorece a eficiência organizacional. No entanto, ainda persistem limitações na redução de transportes urgentes e na integração logística total. Conclui-se que o planejamento de materiais constitui

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um elemento estratégico para fortalecer a competitividade e a resiliência das organizações manufatureiras.

Palavras-chave: Planejamento de Materiais. Custos Logísticos. Indústria Manufatureira. Gestão de Estoques.

RESUMEN

El estudio analiza el impacto de la planeación de materiales en la reducción de costos logísticos dentro de la industria manufacturera, destacando el papel estratégico de herramientas como el *Material Requirements Planning* (MRP). Mediante un enfoque cuantitativo, correlacional y transversal aplicado a 32 empresas manufactureras de Guanajuato, se evaluó la relación entre la gestión de materiales, los inventarios, el transporte y el almacenamiento. Los resultados evidenciaron que una adecuada planeación de materiales contribuye significativamente a disminuir costos logísticos, optimizar inventarios, reducir obsolescencia y mejorar la coordinación operativa. Asimismo, se identificó que la sincronización entre abastecimiento, producción y distribución favorece la eficiencia organizacional. Sin embargo, persisten limitaciones en la reducción de transportes urgentes y en la integración logística total. Se concluye que la planeación de materiales constituye un elemento estratégico para fortalecer la competitividad y resiliencia de las organizaciones manufactureras.

Palabras clave: Planeación de Materiales. Costos Logísticos. Industria Manufacturera. Gestión de Inventarios.

1 INTRODUCTION

In today's manufacturing environment, logistics management has evolved from an exclusively operational activity to a strategic element that is critical to an organization's economic viability, competitiveness, and ability to adapt to different environments. The globalisation of markets, combined with the instability of energy prices, the disruptions of supply chains at an international level and the development of growing expectations of production efficiency have highlighted the importance of global optimisation of logistics processes. In this sense, the costs of transportation, storage, inventory handling, procurement, and distribution become an important part of the overall cost structure of companies. Consequently, its impact on the profit margins and competitive capacity of manufacturing organizations is significant (Khawka et al., 2024; Sharvan & Ustenko, 2025; Zheng & Wang, 2025).

In recent decades, aspects such as rising fuel prices, global inflation, shortages of raw materials, the imposition of trade restrictions and variations in demand have led to a robust growth in logistics prices, which have forced companies to rethink their operating practices under more scientific approaches. predictive and systemic efficiency. From this perspective, material planning is one of the important variables in operations management, as it tries to adjust production needs as best as possible with the rational and always imperfect logic of the availability of inputs; minimizing waste, reducing costs caused by overstocking, avoiding stopping production, and improving coordination with suppliers, in internal processes, and in distribution (Bokor et al., 2024; Javadi, Rabbani & Rafiei, 2026; Nguyen, Wang & Dang, 2025).

Efficient material planning (on which *Material Requirements Planning* (MRP), Just in Time (JIT), *Lean Manufacturing* and advanced demand systems are based) is a fundamental tool to optimize and coordinate the flow of resources throughout the supply chain. in addition to helping to reduce logistics costs associated with storage time, urgent acquisition costs, losses due to obsolescence, financial costs for fixed capital, and risks generated by variability (Rahman, 2025; Reyes, Cañas & Mula, 2026; Yu et al., 2024).

From the frame of reference of a scientific practice, the relationship between the planning of materials and the reduction of logistics costs can be seen as a phenomenon that can be classified as a multidimensional phenomenon in which variables of operational efficiency, inventory control, productivity, technological integration and strategic decision-making are communicated. Therefore, studying the impact of materials planning in the manufacturing industry is not only relevant to understand the mechanisms that favor economic optimization, but also to generate evidence that allows the construction of more robust, sustainable and

adaptive management models in the face of highly competitive environments (Bag et al., 2026; Ghobakhloo et al., 2024; Woschank, Dallasega & Konstantinidis, 2025).

In this context, problems associated with materials management have been identified, such as variations in inventory levels, misalignment between planning and actual demand, as well as an increase in the frequency of urgent shipments. These situations reflect operational inefficiencies. In addition, they generate direct impacts on logistics costs, particularly in storage and transportation. This suggests that the lack of synchronization between logistics processes limits the efficient use of available resources (Kumar, Gunasekaran & Singh, 2026; Li, Zhang & Chen, 2025; Min, 2024).

Despite the relevance of these problems, a comprehensive analysis is required to quantitatively evaluate the impact of requirements management on logistics costs. While the literature recognizes the importance of this relationship, most studies focus on theoretical approaches or simulations. These incorporate some real operating conditions of the production plants. Therefore, to increase empirical evidence, it is necessary to identify concrete strategies aimed at improving logistics efficiency in specific industrial environments.

In this sense, it is necessary to analyze in detail how materials management affects logistics costs. This analysis focuses particularly on inventories, transport and storage. This analysis will identify areas of opportunity aimed at optimizing resources, strengthening operational efficiency, and increasing organizational competitiveness. (Esper & Williams, 2022).

Consequently, the analysis of this topic acquires significant importance in both the academic and business spheres, as it provides foundations to improve industrial competitiveness through planning strategies that strengthen logistics efficiency, reduce structural costs and promote a more effective management of productive resources.

2 THEORETICAL FRAMEWORK

2.1 LOGISTICS AND LOGISTICS COSTS IN THE MANUFACTURING INDUSTRY

Logistics is defined as the process of planning, implementing and efficiently controlling the flow and storage of goods, services and information from the point of origin to consumption, with the aim of satisfying customer requirements at the lowest possible cost. In the manufacturing industry, logistics costs mainly comprise transportation, storage, inventory management, and order management (Gashi, 2026; Pozo & Teodoro Filho, 2026).

Playing a fundamental role due to the complexity of each of the operations, ranging from the supply of raw materials, inventory management to the distribution of finished products and coordination with suppliers and customers. Consequently, logistics costs represent a significant

proportion of total operating costs, becoming a determining factor for the profitability and competitiveness of companies (Woschank, Dallasega, & Konstantinidis, 2025).

According to the *Council of Supply Chain Management Professionals*, logistics costs can represent between 8% and 15% of the value of sales in manufacturing industries, which makes them a critical factor of competitiveness. Therefore, optimizing these costs requires proper integration of logistics processes and efficient resource management (Pozo & Teodoro Filho, 2026).

In line with the above, logistics cost management has evolved towards more comprehensive approaches that seek not only to reduce them, but also to optimize them within the supply chain. Traditionally, companies focused on minimizing individual costs, such as transportation or storage; however, recent literature emphasizes the importance of adopting a systemic view that considers the total logistics cost. This approach makes it possible to identify interrelationships between the different components of cost, avoiding suboptimal decisions that may generate savings in one area, but increases in another (Ghobakhloo, Fathi, Iranmanesh, Maroufkhani & Morales, 2024; Pozo & Teodoro Filho, 2026; Woschank, Dallasega & Konstantinidis, 2025).

One of the most widely used approaches today is *Total Cost of Ownership (TCO)*, which considers all the costs associated with the acquisition, transportation, storage and use of a product throughout its life cycle. Likewise, activity-based costing (ABC) has gained relevance as a tool to allocate costs more accurately to logistics activities, allowing inefficient processes and opportunities for improvement to be identified (Nguyen, Wang & Dang, 2025).

2.2 MATERIAL REQUIREMENTS PLANNING (MRP)

MRP (*Material Requirements Planning*) is a system that allows determining which materials are needed, in what quantity and at what time, based on production demand. Its importance lies in its ability to efficiently coordinate the supply of materials with production requirements, ensuring timely availability and contributing to the optimization of organizational resources.

According to Orlicky Joseph (1975), the MRP is based on three fundamental elements: Bill of Materials (BOM); Master Production Schedule (MPS); Available inventories

The bill of materials (BOM) represents the structure of the product, breaking down all the components, subassemblies and raw materials required and the quantity for the manufacture of a product. This element is key to the operation of the MRP, as it allows the identification of the hierarchical relationship between the different levels of the product and the calculation of

the dependent demand for each of its components (Javadi et al., 2025; Wulung, Putri & Purwoko, 2026). The master production schedule (MPS) establishes which end products are to be produced, in what quantities, and over what time periods. It acts as the starting point for MRP, as it translates market-independent demand into specific production plans. The accuracy of the MPS is critical, as any error in demand estimation can lead to ripple effects throughout the supply chain, such as excess inventories or material shortages (Pekarcikova et al., 2025).

The main objective of MRP is to ensure the availability of materials by avoiding both shortages and excess inventory, which directly impacts logistics costs. Since an insufficient level of inventory can cause interruptions in production and even delays in deliveries with customers, while an excess of inventory increases storage costs, obsolescence and tied up capital. The third element, available inventories, includes information on current stock, orders in transit, lead *times*, and replenishment policies. This component allows the MRP system to calculate material needs, considering both demand and existing availability, which facilitates decision-making ((Javadi et al., 2025; Wulung, Putri & Purwoko, 2026).

Therefore, supply control through MRP is an essential tool for the efficient management of production and logistics in the manufacturing industry. Its correct implementation improves coordination between areas, optimizes inventory levels and reduces logistics costs, thus contributing to the strengthening of organizational competitiveness. However, its effectiveness depends on integration with other management tools, the quality of information and the ability to adapt to dynamic and changing environments.

2.3 INVENTORY MANAGEMENT AND ITS IMPACT ON COSTS

Inventory management is one of the fundamental pillars of logistics as it directly influences storage costs, working capital and service level. In the manufacturing industry, where material flows are constant and highly interdependent, proper inventory management is critical to ensure production continuity and supply chain efficiency. In general, inventory management refers to the set of policies, processes, and tools used to control stock levels of raw materials, products in process, and finished products, with the goal of meeting demand in a timely manner at the lowest possible cost. In this sense, its relevance lies in achieving a balance between availability and efficiency, avoiding both excess and shortage of inventory. According to Donald J. Bowersox (2013), there are three main types of inventory costs: Maintenance costs (storage, insurance); order costs; Costs due to shortages

Maintenance costs, also known as holding costs, include all those expenses associated with storing inventories over time. These encompass physical storage costs, insurance,

deterioration, obsolescence, material handling, and the opportunity cost of capital invested. Various recent studies highlight that these costs can represent between 20% and 30% of the value of the annual inventory, which makes them a critical factor within the logistics cost structure. On the other hand, the order costs correspond to the expenses generated when placing purchase orders. These include administrative costs, order processing, negotiation with suppliers, initial transportation, and receipt of materials. Although individually they may seem minor, their cumulative impact can be significant, especially in environments where high order volumes or high replenishment frequencies are handled (Gashi, 2025).

The third component, shortage costs, refers to losses arising from the lack of inventory when the lawsuit is filed. These costs can manifest themselves in the form of lost sales, contractual penalties, production stoppages or impacts on customer satisfaction. In the manufacturing industry, material shortages can have particularly severe consequences, such as interruptions in the production line, leading to additional costs due to downtime and inefficient use of resources. Efficient material planning allows these costs to be balanced, reducing unnecessary inventories without compromising the productive operation (Rachmat, 2026).

2.4 PLANNING MATERIALS AND STORAGE COSTS

Storage represents a significant cost within the logistics chain, due to its direct impact on the use of physical, financial and operational resources. In this context, materials management plays a critical role in determining inventory levels and, therefore, in the magnitude of costs associated with storage. Inefficient management, particularly in systems such as Material Requirements Planning (MRP), can lead to significant imbalances in inventory levels. When material requirements are not correctly aligned with actual demand or production capacity, an overinventory phenomenon occurs, which considerably increases storage costs (Jin et al., 2025; Rachmat, 2026). Consequently, poor requirements management not only generates inventory surpluses, but also causes: Physical space costs; handling costs; Risk of obsolescence

Physical space costs include the expansion or saturation of warehouses, the need to rent additional space, or even investment in logistics infrastructure. These costs tend to increase proportionally to the volume of inventory, directly affecting the profitability of the operation. Second, there are material handling costs, which encompass activities such as receiving, internal transfer, storage, assortment, and dispatch. A higher volume of inventory implies greater frequency and complexity in these operations, which translates into an increase in the use of labor, equipment and operating time.

In addition, the risk of obsolescence represents one of the most critical costs associated with excess inventory, especially in industrial environments characterized by rapid technological changes or variability in demand. Materials that remain in storage for long periods can lose value, become obsolete or even unusable, generating significant economic losses for the organization. On the contrary, proper planning reduces inventory levels and optimizes the use of warehouses, which directly impacts the optimization of the use of logistics resources. However, it is important to note that inventory reduction must be done strategically, considering factors such as demand variability, delivery times, and supplier reliability. Excessive reduction can increase the risk of shortages and generate costs greater than the savings obtained in storage. Therefore, the challenge is to find an optimal balance that minimizes costs without compromising operational continuity (Yusof et al., 2026).

2.5 PLANNING OF MATERIALS AND TRANSPORTATION COSTS

Transportation represents one of the most significant components within logistics costs in the manufacturing industry, due to its essential role in the movement of materials and products throughout the supply chain. In this context, material planning has a direct influence on transport efficiency. When there is poor planning, companies resort to urgent or fragmented shipments, which increases costs. Efficient planning allows: Consolidation of loads; route scheduling; Reduction of urgent shipments.

Cargo consolidation allows you to significantly optimize transportation costs by implementing various logistics strategies. One of the most relevant is this one, which consists of grouping multiple orders or materials into a single shipment, maximizing the utilization of transport capacity and reducing the cost per unit. This strategy not only decreases direct transportation costs, but also contributes to the reduction of emissions and the more efficient use of resources (Gashi, 2025).

Another key strategy is route scheduling, which allows transportation routes to be planned in advance, considering factors such as supplier locations, delivery times, load capacity, and traffic conditions. The use of digital tools such as Transportation Management Systems (TMS) has facilitated route optimization, allowing for reduced distances traveled, delivery times, and operating costs.

Likewise, adequate control of materials contributes to reducing urgent shipments, which represent one of the main generators of cost overruns in logistics. By having accurate and demand-aligned planning, companies can anticipate their needs and schedule regular shipments, avoiding resorting to emergency solutions that significantly increase costs.

Managing the supply of materials has a direct impact on transportation costs, as it influences the way logistics movements are organized and executed. Efficient planning allows for the consolidation of loads, optimize routes, and reduce urgent shipments, which translates into a significant decrease in transportation costs and an improvement in supply chain performance (Yusof et al., 2026)

2.6 SUPPLY CHAIN COORDINATION

The input planning process does not operate in isolation within the organization, but is part of a larger system known as the supply chain, which integrates fundamental coordination. In this sense, effective coordination between these functions is essential to ensure operational efficiency, cost rationalization and compliance with customer service levels. Within this network, the materials management system acts as an articulating element that allows aligning production requirements with the availability of inputs and distribution capacity, which requires coordination between: Supply; production; distribution.

First, coordination with the sourcing area is essential to ensure the timely supply of materials. Proper planning allows you to generate purchase orders in advance, negotiate better conditions with suppliers and reduce uncertainty in delivery times. On the contrary, a lack of coordination can generate delays, urgent purchases and higher logistics costs, affecting the continuity of the productive operation. Second, integration with the shop floor is key to synchronizing material availability with manufacturing plans. The MRP system, being based on the master production schedule, facilitates this alignment; however, its effectiveness depends on the accuracy of the information and communication between the areas involved. A lack of coordination can generate problems such as line stoppages, downtime or accumulation of inventories in process.

On the other hand, coordination with the distribution area allows the efficient planning of the delivery of finished products to the customer. This involves considering factors such as delivery times, transportation routes, inventory levels in distribution centers, and market demand. According to Christopher (2016), supply chain integration reduces uncertainty, improves process synchronization, and lowers operating costs (Rachmat, 2026).

2.7 DYNAMIC ENVIRONMENTS AND LOGISTICAL RESILIENCE

In recent years, the manufacturing industry has undergone a significant transformation, stemming from highly dynamic and uncertain environments. Factors such as the COVID-19 pandemic, geopolitical tensions, disruption in global supply chains, and emerging trends such

as nearshoring have increased volatility in both demand and supply of materials. In this context, the input planning process acquires strategic relevance, as it becomes a key element to guarantee operational continuity and organizational stability.

Dynamic environments are characterized by constant and unpredictable changes in variables such as market demand, delivery times, availability of inputs, and logistics costs. Under these conditions, traditional planning models may be insufficient if they do not incorporate adaptation and flexibility mechanisms. For this reason, recent literature emphasizes the need to evolve towards more resilient planning systems, capable of anticipating and responding effectively to disruptions (Ferrari & Pesaresi, 2025; Shahnawaz & Safder, 2026). Adequate planning allows: Adaptation to changes in demand; reduction of shortages risks; greater organizational resilience.

Comprehensive input management contributes, first of all, to adaptation to changes in demand. In volatile environments, demand can fluctuate significantly over short periods of time, requiring flexible and up-to-date planning systems. The use of tools such as predictive analytics, Advanced Planning Systems (APS), and real-time data integration allows production and supply plans to be adjusted dynamically, reducing deviations and improving accuracy in decision-making (Min, 2025; Safder & Shahnawaz, 2026).

Efficient planning allows the reduction of shortages risks, one of the main problems in contexts of uncertainty. Supplier diversification, supply chain risk assessment, and the definition of safety inventory levels are strategies that, supported by proper planning, mitigate disruptions in the supply of materials. This is especially relevant in the automotive industry, where the lack of a single component can bring production to a complete halt.

Likewise, material requirements planning contributes to the development of greater organizational resilience, by facilitating the implementation of strategies such as supplier regionalization (nearshoring), the digitization of processes, and the integration of information throughout the supply chain. These practices reduce dependence on distant or unstable sources, improve visibility into operations, and strengthen response capacity to unexpected events.

Therefore, in dynamic and highly uncertain environments, materials planning becomes a strategic element to strengthen the logistical resilience of organizations. Its proper implementation allows it to adapt to changes in demand, reduce the risk of shortages and improve the capacity to respond to disruptions, thus contributing to operational stability and the efficient control of logistics costs.

2.8 RELATIONSHIP BETWEEN MATERIAL PLANNING AND LOGISTICS COSTS

The input planning process is a central element within supply chain management, due to its direct and comprehensive impact on the different components of logistics costs. In the manufacturing industry, where operational efficiency is key to competitiveness, the correct alignment between demand, production and supply allows resources to be optimized and costs minimized throughout the chain. Various studies agree that there is a direct relationship between material planning and the reduction of logistics costs (Dolgui, Ivanov & Sokolov, 2025; Rachmat, 2026). since it simultaneously influences critical areas such as: Inventories; transportation; storage; service level.

This relationship is not isolated, but systemic, which implies that an improvement in planning can generate positive effects in multiple operational dimensions. Therefore, proper materials management becomes a strategic factor to improve the efficiency and competitiveness of manufacturing organizations.

3 OBJECT OF RESEARCH

3.1 GENERAL OBJECTIVE

Analyze the influence of raw material requirements planning on logistics costs, evaluating its impact on inventory management, transportation, and storage, in order to identify opportunities for improvement aimed at optimizing resources and strengthening operational efficiency.

3.2 SPECIFIC OBJECTIVE

1. Analyze the current materials management process. Through the structured evaluation of requirements planning (MRP), demand management, delivery times and coordination between areas, in order to identify operational deviations and their impact on actual execution.
2. Quantify the impact of requirements management on inventory levels. Through the analysis of indicators such as inventory turnover, inventory days and stock levels, in order to identify excesses or shortages and determine their effect on maintenance costs and working capital.
3. Determine the relationship between supply management and transportation costs. By analyzing variables such as the frequency of urgent shipments, cargo consolidation, and logistics scheduling, with the aim of identifying patterns of inefficiency and opportunities for cost reduction.

4. Evaluate the impact of material planning on storage costs. Through the measurement of space usage, inventory turnover, and warehouse operating costs, in order to identify inefficiencies and quantify areas of optimization.
5. Propose strategies for improvement in planning of material requirements, based on the quantitative analysis of the results obtained, aimed at reducing logistics costs, optimizing resources and improving the operational efficiency of the plant.

Based on the theoretical foundations presented and the review of the literature, the following research hypotheses are formulated:

3.3 RESEARCH HYPOTHESIS

3.3.1 General hypothesis

- **H1:** Material planning has a significant influence on the reduction of logistics costs. Because it allows for better synchronization between demand, production, and supply, which translates into optimized inventory levels, greater transportation efficiency, and more appropriate use of storage resources.

This hypothesis is based on the premise that raw material planning, through tools such as Material Requirements Planning (MRP), allows to efficiently align production requirements with the availability of inputs. This alignment reduces operational deviations that commonly generate cost overruns within the logistics chain. Firstly, proper materials management contributes to the optimisation of inventory levels, avoiding both excess and shortages. This has a direct impact on the reduction of different costs, such as storage and working capital. When materials are planned accurately, the need to maintain high inventories as a safety measure is reduced.

Second, materials management influences transportation efficiency by scheduling shipments in advance, consolidating loads, and avoiding urgent transports. On the contrary, poor management generates extraordinary shipments, which significantly increase logistics costs due to their urgent nature. Likewise, a correct planning of material requirements favors the optimization of storage, by reducing space saturation and improving inventory turnover. This translates into lower costs and we avoid the risk of obsolescence. In this sense, material planning not only has an individual impact on each component of the logistics cost, but also generates an integral effect on the entire supply chain, by improving coordination between the different areas involved. Therefore, it is proposed that an improvement in the management of inputs will result in a significant decrease in total logistics costs.

3.3.2 Specific hypotheses

- **H1a:** Proper planning of material requirements is associated with a decrease in storage costs, measured through the average inventory level and days of inventory.
- **H1b:** Efficient material planning relates to a reduction in transportation costs, measured by decreasing the frequency of urgent shipments and improving freight consolidation.
- **H1c:** Efficient inventory management is associated with the reduction of costs due to overstock and shortages, evaluated through indicators such as inventory turnover, stock level and frequency of shortages.
- **H1d:** The coordination between supply, production and distribution is related to an improvement in logistics costs, measured by reducing variations in the scheduling of materials and reducing operating costs.

4 METHODOLOGY

4.1 RESEARCH APPROACH

This study is developed under a quantitative approach, because it is oriented to the collection and analysis of numerical data in order to identify the relationship between the planning of material requirements and logistics costs. This approach makes it possible to measure the study variables through specific indicators and to apply statistical techniques that facilitate the verification of the hypotheses raised.

4.2 TYPE AND DESIGN

The research is non-experimental, because the study variables are not manipulated, but are analyzed in their natural context within the manufacturing industry. It also has a cross-sectional design, since data collection will be carried out at a single moment in time. Finally, the study is correlational in scope, since it seeks to determine the degree of relationship between the planning of material requirements as an independent variable and logistics costs as a dependent variable.

4.3 POPULATION AND SAMPLE

The study population is made up of personnel from the logistics, production, and supply areas of the manufacturing industry of the State of Guanajuato, due to their direct participation in processes related to materials management and logistics costs. For data collection, a sample of 32 participating companies was randomly selected through a non-probabilistic convenience sampling, considering the accessibility to the database and their direct participation in the

processes. This sample size allows obtaining relevant information for the analysis of the variables under study.

Likewise, it was sought that the participating companies had direct experience in the planning, inventory, transport and storage processes, which guaranteed the relevance and quality of the information collected. Although the sample size does not allow a statistical generalization to the entire population, it is sufficient to identify trends and analyze the relationship between the study variables in the specific context.

4.4 INSTRUMENT

A structured questionnaire-type instrument was developed, which is composed of 15 items distributed along three strategic dimensions, namely: materials planning, logistics costs and operational coordination, which aims to quantitatively evaluate the relationship between the efficiency of materials management and the impact they have on logistics costs in the organization. This instrument was developed under a five-point Likert scale, where the value 1 corresponds to "strongly disagree" and 5 "strongly agree", and thus allows to evaluate the degree of perception presented by them, with respect to the various operational, administrative and strategic practices in relation to the planning of material resources.

The first aspect, materials planning, had an objective aimed at studying the implementation of systems such as *Material Requirement Planning* (MRP), accuracy in demand forecasting, coordination between supply and production, as well as the ability of planning to generate possible stock shortages, reduce excess inventory, and improve operational productivity.

The second dimension, logistics costs, was used to study the effect of the aforementioned practices on the most important economic variables of the study, including warehouse-related costs, reduction of urgent transports, reduction of the risk of obsolescence, improvement in the use of warehouses and general reduction of logistics costs. etc. And the dimension of operational coordination was the area that allowed us to study the strategic impact of integration between different departments and the anticipation with which operational problems arising from planning deficiencies can be addressed.

Methodologically, the questionnaire was applied to the managers of the selected companies, directly involved in carrying out the logistics, supply, planning or manufacturing processes of the company used as the object of study, ensuring that the answers came from social actors with operational and also strategic knowledge about the behavior of materials. The information obtained was treated through descriptive statistical analysis, using central tendency

measures such as means and standard deviations to detect generalized patterns of organizational perception; on the other hand, the application of reliability analysis using Cronbach's Alpha coefficient of 80% was also contemplated, which validated the internal consistency of the instrument, as well as correlational analysis to determine if there is any relationship between the planning of materials and the alteration of logistics cost.

This methodological approach made it possible to obtain quantifiable results on the importance of the implementation of efficient planning systems in the form of a tool to strengthen business competitiveness, optimize resources, reduce costs and facilitate the total coordination of the *supply chain*. In this way, the instrument used was not only an organizational diagnostic mechanism, but also the scientific basis for the implementation of new strategies for continuous improvement in logistics and operations management.

4.5 STATISTICAL ANALYSIS

The analysis of the data obtained objectively through the measurement instrument was carried out following a quantitative approach using descriptive and inferential techniques that sought to evaluate the general behavior of the variables analyzed and their relationship with each other.

A preliminary descriptive analysis was carried out as it was carried out by calculating arithmetic means and, for each item and for each dimension of the questionnaire (material planning, logistics costs and operational coordination), this allowed detecting measures of central tendency of the subjects' responses, while facilitating the interpretation of the level of organizational perception regarding the efficiency of the planning of materials that sustains the operation of logistics operations. The measures that were finally obtained provided decisive information regarding the strengths, weaknesses and areas for improvement present in the processes analyzed, since superior measures denote a positive opinion about the effectiveness of the practices applied.

Subsequently, Pearson's correlation coefficient (r) was used as an inferential analysis resource to determine the intensity and direction of the linear relationship between the variables that constitute the core of the pattern of this study. By virtue of these aspects, the test also allowed to evaluate the strength of the relationship since both the adequate planning of materials and the reduction of logistics costs (in terms of correct planning of materials) are studied, and in the same way between coordination and organizational effectiveness. Pearson's correlation was chosen because it is particularly valid for measuring relationships between continuous quantitative variables resulting from Likert scales considered as interval variables,

in the context of studies of organizational issues. Its value is always located between -1 and +1, having to: a positive value expresses that there is a direct relationship, a negative value presents an inverse relationship and the proximity to zero denotes the absence of a significant relationship.

The conjunction of both techniques progressively made it possible to support the integrative analysis of both tests: describing on the one hand the general behavior of the sample and on the other the statistical evidence of the association of planning processes and that of logistics costs. This procedure also reinforces the purported scientific validity of the study since it allows the substantiation of the conclusions objectively by focusing on the strategic influence that materials management exerts on the performance and restriction of logistics in organizations. Thus, the application of statistical analysis is part of the study since it allows transforming the data collected into empirical evidence that is useful both for decision-making and for the determination of organizational optimization strategies.

5 RESULTS

5.1 DESCRIPTIVE ANALYSIS OF MATERIALS PLANNING

The results show that the material planning dimension presents a positive overall assessment, with averages above 3.5 in most of the items, which indicates a favorable perception regarding the implementation of planning tools such as the MRP.

In particular, the item related to the planning capacity to avoid material shortages obtained a high mean ($M = 4.429$, $SD = 0.535$), which suggests an adequate alignment between production requirements and the supply of inputs. Similarly, it was observed that planning contributes to the reduction of excess inventory ($M = 4.143$, $SD = 1.069$) and to the optimization of warehouse use ($M = 4.143$, $SD = 0.690$), evidencing a positive impact on inventory management.

However, relevant areas of opportunity were identified. The item referring to the reduction of urgent transport presented the lowest mean ($M = 2,714$, $SD = 1,496$), which indicates deficiencies in logistics synchronization. Likewise, the perception of the decrease in storage costs was moderate ($M = 3,286$, $SD = 1,254$), which suggests that the economic benefits derived from planning are not yet fully reflected in the operation (See Table 1)

Table 1

Analysis of means and standard deviation material planning section (n=32)

Items	$\bar{X}$	SD
Materials Section		

1. Tools such as MRP are used appropriately to plan requirements.	3.857	0.690
2. The demand for materials is correctly forecasted.	3.714	1.113
3. There is effective coordination between supply and production.	3.857	0.900
4. Planning avoids shortages of materials.	4.429	0.535
5. Planning reduces excess inventory.	4.143	1.069
6. Planning systems (MRP) are efficient.	3.571	1.134
7. Material scheduling improves production operation.	4.000	0.577
8. Storage costs have decreased thanks to planning.	3.286	1.254
9. Proper material planning reduces the need for urgent transport.	2.714	1.496
10. The company minimizes losses due to obsolete inventory.	3.571	1.272
11. Planning optimizes the use of the warehouse.	4.143	0.690
12. Overall logistics costs have decreased.	3.857	1.069
13. Materials planning has a direct impact on logistics costs.	4.286	0.756
14. Poor planning increases operating costs.	4.571	0.535
15. Coordination between areas allows anticipating problems in the operation.	4.571	0.535

Source: Authors.

5.2 DESCRIPTIVE ANALYSIS OF LOGISTICS COSTS

In the dimension of logistics costs, the results reflect a moderate perception regarding cost reduction, with averages ranging between 3.2 and 4.6. Coordination between areas obtained the highest score ($M = 4.600$, $SD = 0.548$), confirming its fundamental role in operational efficiency.

Likewise, it was observed that planning contributes to the optimization of warehouse use ($M = 4.200$, $SD = 0.447$) and to the reduction of shortages ($M = 4.200$, $SD = 0.837$). However, the efficiency of the MRP systems was evaluated with a lower mean ($M = 3.200$, $SD = 0.837$), which shows possible limitations in their implementation or integration.

In addition, the overall reduction in logistics costs ($M = 3.600$, $SD = 1.140$) and the minimization of obsolete inventories ($M = 3.400$, $SD = 1.140$) show a partial impact, suggesting that, although there are operational improvements, these do not fully translate into tangible economic benefits (See Table 2).

Table 2

Analysis of means and standard deviation of logistics costs section (n=32)

Items	$\bar{X}$	SD
Materials Section		
1. Tools such as MRP are used appropriately to plan requirements.	3.800	0.837
2. The demand for materials is correctly forecasted.	3.600	1.140
3. There is effective coordination between supply and production.	3.600	0.894
4. Planning avoids shortages of materials.	4.200	0.837
5. Planning reduces excess inventory.	3.600	1.517
6. Planning systems (MRP) are efficient.	3.200	0.837
7. Material scheduling improves production operation.	4.000	1.000
8. Storage costs have decreased thanks to planning.	3.800	0.837
9. Proper material planning reduces the need for urgent transport.	3.600	1.140
10. The company minimizes losses due to obsolete inventory.	3.400	1.140
11. Planning optimizes the use of the warehouse.	4.200	0.447
12. Overall logistics costs have decreased.	3.600	1.140
13. Materials planning has a direct impact on logistics costs.	4.400	0.548
14. Poor planning increases operating costs.	3.800	1.095
15. Coordination between areas allows anticipating problems in the operation.	4.600	0.548

Source: Authors.

5.3 DESCRIPTIVE ANALYSIS OF OPERATIONAL COORDINATION.

The operational coordination dimension presented consistent results, highlighting high levels in the ability to avoid shortages ($M = 4.524$, $SD = 0.814$) and reduce excess inventory ($M = 4.524$, $SD = 0.680$). These findings show an adequate integration between the areas of supply, production and logistics.

Likewise, the programming of materials was perceived as an element that improves the productive operation ($M = 4.381$, $SD = 0.973$). However, the minimization of obsolete inventories ($M = 3,048$, $SD = 1,117$) and the reduction of urgent transports ($M = 3,429$, $SD = 1,248$) continue to represent areas for improvement.

Taken together, these results indicate that, although operational coordination is strong, there are still limitations in eliminating logistical inefficiencies, particularly in dynamic environments (See Table 3)

Table 3

Analysis of means and standard deviation material planning section (n=32)

Items	$\bar{X}$	SD
Materials Section		
1. Tools such as MRP are used appropriately to plan requirements.	3.905	1.091
2. The demand for materials is correctly forecasted.	3.857	0.727
3. There is effective coordination between supply and production.	3.810	0.873
4. Planning avoids shortages of materials.	4.524	0.814
5. Planning reduces excess inventory.	4.524	0.680
6. Planning systems (MRP) are efficient.	3.905	0.944
7. Material scheduling improves production operation.	4.381	0.973
8. Storage costs have decreased thanks to planning.	3.714	1.189
9. Proper material planning reduces the need for urgent transport.	3.429	1.248
10. The company minimizes losses due to obsolete inventory.	3.048	1.117
11. Planning optimizes the use of the warehouse.	4.190	1.078
12. Overall logistics costs have decreased.	3.619	1.024
13. Materials planning has a direct impact on logistics costs.	4.143	1.014
14. Poor planning increases operating costs.	4.571	0.978
15. Coordination between areas allows anticipating problems in the operation.	4.571	0.978

Source: Authors.

5.4 CORRELATIONAL ANALYSIS

5.4.1 Hypothesis H1a: Relationship between material planning and logistics costs

Pearson's correlation analysis showed positive and significant relationships between the use of planning tools (MRP) and the reduction of logistics costs ($r = 0.826$, $p < 0.05$), as well as with the minimization of obsolete inventories ($r = 0.925$, $p < 0.01$). These results confirm that adequate material planning contributes significantly to logistics efficiency. However, negative

correlations were identified in relation to the reduction of urgent transports ($r = -0.482$), which shows limitations in logistics synchronization.

Table 4

Association between the use of the ERP platform with the variables of material planning, costs, operational coordination. (n=32)

H1a	
Items	Correlation
Section I Materials	
1. Tools such as MRP are used appropriately to plan requirements.	.826*
2. The demand for materials is correctly forecasted.	0.666
3. There is effective coordination between supply and production.	0.633
4. Planning avoids shortages of materials.	0.284
5. Planning reduces excess inventory.	0.213
6. Planning systems (MRP) are efficient.	0.687
7. Material scheduling improves production operation.	0.691
9. Proper material planning reduces the need for urgent transport.	-0.482
10. The company minimizes losses due to obsolete inventory.	.925**
11. Planning optimizes the use of the warehouse.	0.716
12. Overall logistics costs have decreased.	.782*
13. Materials planning has a direct impact on logistics costs.	0.427
14. Poor planning increases operating costs.	-0.533
15. Coordination between areas allows anticipating problems in the operation.	-0.036
Section II Costs	
1. Tools such as MRP are used appropriately to plan requirements.	-0.356
2. The demand for materials is correctly forecasted.	-0.850
3. There is effective coordination between supply and production.	0.583
4. Planning avoids shortages of materials.	-0.312

5. Planning reduces excess inventory.	-0.147
6. Planning systems (MRP) are efficient.	-0.535
7. Material scheduling improves production operation.	-0.186
8. Storage costs have decreased thanks to planning.	-0.579
9. Proper material planning reduces the need for urgent transport.	-0.523
10. The company minimizes losses due to obsolete inventory.	-.948*
11. Planning optimizes the use of the warehouse.	-0.583
12. Overall logistics costs have decreased.	0.131
13. Materials planning has a direct impact on logistics costs.	0.068
14. Poor planning increases operating costs.	-0.782
15. Coordination between areas allows anticipating problems in the operation.	-0.408

Section III Operational coordination

1. Tools such as MRP are used appropriately to plan requirements.	-0.266
2. The demand for materials is correctly forecasted.	-0.266
3. There is effective coordination between supply and production.	0.000
4. Planning avoids shortages of materials.	-0.314
5. Planning reduces excess inventory.	0.075
6. Planning systems (MRP) are efficient.	-0.251
7. Material scheduling improves production operation.	0.427
8. Storage costs have decreased thanks to planning.	-0.523
9. Proper material planning reduces the need for urgent transport.	0.031
10. The company minimizes losses due to obsolete inventory.	-0.570
11. Planning optimizes the use of the warehouse.	-0.619
12. Overall logistics costs have decreased.	-0.479
13. Materials planning has a direct impact on logistics costs.	-0.248
14. Poor planning increases operating costs.	-0.362
15. Coordination between areas allows anticipating problems in the operation.	-0.145

* $p < 0.05$

** $p < 0.01$

Source: Authors.

5.4.2 Hypothesis H1b: Material and Transportation Cost Planning

Positive correlations were observed between demand forecasting and reduction of logistics costs ($r = 0.801$, $p < 0.05$), as well as with storage costs ($r = 0.782$, $p < 0.05$). However, the negative correlations associated with transport indicate that this dimension remains a critical area within the logistics system.

Table 5

Association of logistics cost reduction with the variables of material planning, costs, operational coordination. (n=32)

H1b	
Items	Correlation
Section I Materials	
1. Tools such as MRP are used appropriately to plan requirements.	0.420
2. The demand for materials is correctly forecasted.	.801*
3. There is effective coordination between supply and production.	0.149
4. Planning avoids shortages of materials.	0.125
5. Planning reduces excess inventory.	0.604
6. Planning systems (MRP) are efficient.	0.354
7. Material scheduling improves production operation.	0.270
8. Storage costs have decreased thanks to planning.	.782*
9. Proper material planning reduces the need for urgent transport.	-0.238
10. The company minimizes losses due to obsolete inventory.	0.683
11. Planning optimizes the use of the warehouse.	0.484
13. Materials planning has a direct impact on logistics costs.	0.265
14. Poor planning increases operating costs.	-0.417
15. Coordination between areas allows anticipating problems in the operation.	0.167
Section II Costs	
1. Tools such as MRP are used appropriately to plan requirements.	-0.643

2. The demand for materials is correctly forecasted.	-0.943*
3. There is effective coordination between supply and production.	0.134
4. Planning avoids shortages of materials.	-0.786
5. Planning reduces excess inventory.	-0.512
6. Planning systems (MRP) are efficient.	-0.786
7. Material scheduling improves production operation.	-0.598
8. Storage costs have decreased thanks to planning.	-0.643
9. Proper material planning reduces the need for urgent transport.	-0.681
10. The company minimizes losses due to obsolete inventory.	-0.891*
11. Planning optimizes the use of the warehouse.	-0.802
12. Overall logistics costs have decreased.	-0.419
13. Materials planning has a direct impact on logistics costs.	-0.218
14. Poor planning increases operating costs.	-0.491
15. Coordination between areas allows anticipating problems in the operation.	-0.327

Section III Operational coordination

1. Tools such as MRP are used appropriately to plan requirements.	-0.156
2. The demand for materials is correctly forecasted.	0.000
3. There is effective coordination between supply and production.	0.000
4. Planning avoids shortages of materials.	-0.311
5. Planning reduces excess inventory.	-0.147
6. Planning systems (MRP) are efficient.	-0.059
7. Material scheduling improves production operation.	0.471
8. Storage costs have decreased thanks to planning.	-0.258
9. Proper material planning reduces the need for urgent transport.	-0.532
10. The company minimizes losses due to obsolete inventory.	-0.354
11. Planning optimizes the use of the warehouse.	-0.539
12. Overall logistics costs have decreased.	-0.211
13. Materials planning has a direct impact on logistics costs.	-0.194
14. Poor planning increases operating costs.	-0.481

15. Coordination between areas allows anticipating problems in the operation. -0.311

* $p < 0.05$

** $p < 0.01$

Source: Authors.

5.4.3 Hypothesis H1c: Material planning and obsolescence reduction

The results showed strong correlations between the efficiency of the MRP system and the minimization of obsolete inventories ($r = 0.891$, $p < 0.01$), as well as with the reduction of storage costs ($r = 0.925$, $p < 0.01$). These findings confirm the effectiveness of planning in inventory management.

Table 6

Association of minimization of obsolete with the variables of material planning, costs, operational coordination. (n=32)

H1c	
Items	Correlation
Section I Materials	
1. Tools such as MRP are used appropriately to plan requirements.	.868*
2. The demand for materials is correctly forecasted.	0.723
3. There is effective coordination between supply and production.	0.666
4. Planning avoids shortages of materials.	0.560
5. Planning reduces excess inventory.	-0.070
6. Planning systems (MRP) are efficient.	.891**
7. Material scheduling improves production operation.	0.681
8. Storage costs have decreased thanks to planning.	.925**
9. Proper material planning reduces the need for urgent transport.	-0.513
11. Planning optimizes the use of the warehouse.	0.651
12. Overall logistics costs have decreased.	0.683
13. Materials planning has a direct impact on logistics costs.	0.668

14. Poor planning increases operating costs.	-0.560
15. Coordination between areas allows anticipating problems in the operation.	-0.315

Section II Costs

1. Tools such as MRP are used appropriately to plan requirements.	-0.276
2. The demand for materials is correctly forecasted.	-0.839
3. There is effective coordination between supply and production.	0.590
4. Planning avoids shortages of materials.	-0.512
5. Planning reduces excess inventory.	-0.087
6. Planning systems (MRP) are efficient.	-0.512
7. Material scheduling improves production operation.	-0.165
8. Storage costs have decreased thanks to planning.	-0.670
9. Proper material planning reduces the need for urgent transport.	-0.405
10. The company minimizes losses due to obsolete inventory.	-.896*
11. Planning optimizes the use of the warehouse.	-0.590
12. Overall logistics costs have decreased.	0.029
13. Materials planning has a direct impact on logistics costs.	-0.060
14. Poor planning increases operating costs.	-0.662
15. Coordination between areas allows anticipating problems in the operation.	-0.542

Section III Operational coordination

1. Tools such as MRP are used appropriately to plan requirements.	-0.262
2. The demand for materials is correctly forecasted.	-0.262
3. There is effective coordination between supply and production.	0.000
4. Planning avoids shortages of materials.	-0.618
5. Planning reduces excess inventory.	-0.198
6. Planning systems (MRP) are efficient.	-0.149
7. Material scheduling improves production operation.	0.322
8. Storage costs have decreased thanks to planning.	-0.651
9. Proper material planning reduces the need for urgent transport.	0.062

10. The company minimizes losses due to obsolete inventory.	-0.660
11. Planning optimizes the use of the warehouse.	-.807*
12. Overall logistics costs have decreased.	-0.531
13. Materials planning has a direct impact on logistics costs.	-0.488
14. Poor planning increases operating costs.	-0.547
15. Coordination between areas allows anticipating problems in the operation.	-0.285

* p < 0 .05

** p < 0.01

Source: Authors.

5.4.4 Scenario H1d: Operational coordination and logistics costs

Based on Table 4.4, it can be seen that coordination between areas shows significant correlations with material scheduling ($r = 0.963$, $p < 0.01$) and the integration between supply and production ($r = 0.919$, $p < 0.05$). This shows that operational coordination is a key factor in logistics efficiency.

Table 7

Association of coordination between areas with the variables of material planning, costs, operational coordination. (n=32)

H1d	
Items	Correlation
Section I Materials	
1. Tools such as MRP are used appropriately to plan requirements.	.767*
2. The demand for materials is correctly forecasted.	0.119
4. Planning avoids shortages of materials.	0.495
5. Planning reduces excess inventory.	-0.149
6. Planning systems (MRP) are efficient.	0.583
7. Material scheduling improves production operation.	.963**
8. Storage costs have decreased thanks to planning.	0.633

9. Proper material planning reduces the need for urgent transport.	-0.283
10. The company minimizes losses due to obsolete inventory.	0.666
11. Planning optimizes the use of the warehouse.	0.307
12. Overall logistics costs have decreased.	0.149
13. Materials planning has a direct impact on logistics costs.	0.315
14. Poor planning increases operating costs.	-0.149
15. Coordination between areas allows anticipating problems in the operation.	-0.149

Section II Costs

1. Tools such as MRP are used appropriately to plan requirements.	0.218
2. The demand for materials is correctly forecasted.	-0.480
3. There is effective coordination between supply and production.	.919*
4. Planning avoids shortages of materials.	0.055
5. Planning reduces excess inventory.	0.241
6. Planning systems (MRP) are efficient.	-0.218
7. Material scheduling improves production operation.	0.228
8. Storage costs have decreased thanks to planning.	-0.055
9. Proper material planning reduces the need for urgent transport.	-0.080
10. The company minimizes losses due to obsolete inventory.	-0.520
11. Planning optimizes the use of the warehouse.	0.102
12. Overall logistics costs have decreased.	0.721
13. Materials planning has a direct impact on logistics costs.	0.583
14. Poor planning increases operating costs.	-0.875
15. Coordination between areas allows anticipating problems in the operation.	-0.167

Section III Operational coordination

1. Tools such as MRP are used appropriately to plan requirements.	0.000
2. The demand for materials is correctly forecasted.	-0.370

3. There is effective coordination between supply and production.	0.000
4. Planning avoids shortages of materials.	-0.370
5. Planning reduces excess inventory.	0.315
6. Planning systems (MRP) are efficient.	-0.070
7. Material scheduling improves production operation.	-0.175
8. Storage costs have decreased thanks to planning.	-0.575
9. Proper material planning reduces the need for urgent transport.	0.436
10. The company minimizes losses due to obsolete inventory.	-0.420
11. Planning optimizes the use of the warehouse.	-0.640
12. Overall logistics costs have decreased.	-0.445
13. Materials planning has a direct impact on logistics costs.	-0.499
14. Poor planning increases operating costs.	-0.101
15. Coordination between areas allows anticipating problems in the operation.	-0.135

* $p < 0.05$

** $p < 0.01$

Source: Authors.

6 CONCLUSION

The results obtained allow us to conclude that the planning of materials significantly influences the reduction of logistics costs, validating the general hypothesis of the research. Empirical evidence shows that the implementation of tools such as MRP contributes to improving inventory management, optimizing warehouse use and reducing obsolescence. However, the impact of planning is not uniform in all the dimensions analyzed. Important limitations were identified in the reduction of urgent transports, suggesting deficiencies in the synchronization between planning and logistics execution. Also, while coordination between areas is adequate, it is not enough to completely eliminate operational inefficiencies. In this sense, materials planning should be understood as a strategic element whose effectiveness depends on its integration with other systems, the quality of information and the ability to adapt to dynamic environments.

7 LINES OF FUTURE RESEARCH

Based on the findings obtained, the following lines of research are proposed:

1. Analyze the implementation of predictive analytics tools to improve the accuracy of demand forecasting and reduce urgent transports.
2. Evaluate the integration of digital systems (ERP, TMS and APS) in real time to optimize logistics coordination.
3. Develop longitudinal studies that allow analyzing the impact of materials planning over time.
4. Conduct comparative studies across different industry sectors to identify generalizable patterns.
5. Design optimization models focused on cargo consolidation and transportation cost reduction.

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USE AND KNOWLEDGE OF ELECTRONIC CIGARETTES AMONG UNIVERSITY STUDENTS: CAN HEALTH PROMOTION TRANSFORM THIS SCENARIO?

USO E CONHECIMENTO DO CIGARRO ELETRÔNICO ENTRE UNIVERSITÁRIOS: A PROMOÇÃO DA SAÚDE PODE TRANSFORMAR ESSE CENÁRIO?

USO Y CONOCIMIENTO DE LOS CIGARRILLOS ELECTRÓNICOS ENTRE ESTUDIANTES UNIVERSITARIOS: ¿PUEDE LA PROMOCIÓN DE LA SALUD TRANSFORMAR ESTE PANORAMA?



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ABSTRACT

Health promotion plays an essential role in understanding and addressing the growing use of e-cigarettes among university students, especially given the influence of digital media and the social normalization of these devices. E-cigarette use has increased among young people and adults, driven by misconceptions of lower risk and the widespread circulation of unqualified information. This study aimed to analyze the use of and knowledge about e-cigarettes among university students and to evaluate how health promotion can transform this scenario. The research was conducted in 2024 with 275 students using a structured online questionnaire. The results showed that 36% had already used the device, with 18.2% being current users. Use was associated with younger age groups, alcohol consumption, and illicit drug use. The majority perceive e-cigarettes as commonplace in daily life, and 92.7% believe they cause addiction. Informal media was the main source of information, highlighting vulnerability to misinformation. It is concluded that health promotion actions such as critical education, qualified communication, and the creation of healthy university environments are fundamental to reducing risks, strengthening student autonomy, and preventing the early use of these devices.

Keywords: Electronic Cigarettes. Students. Health Promotion. Risk Behavior. Social Media. Nicotine Dependence.

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RESUMO

A Promoção da Saúde tem papel essencial na compreensão e enfrentamento do uso crescente de cigarros eletrônicos entre universitários, especialmente diante da influência das mídias digitais e da normalização social desses dispositivos. O uso do cigarro eletrônico tem crescido entre jovens e adultos, impulsionado por percepções equivocadas de menor risco e pela ampla circulação de informações não qualificadas. Este estudo teve como objetivo analisar o uso e o conhecimento sobre o cigarro eletrônico entre estudantes universitários e avaliar como a Promoção da Saúde pode transformar esse cenário. A pesquisa foi realizada em 2024 com 275 estudantes, por meio de um questionário estruturado aplicado online. Os resultados mostraram que 36% já utilizaram o dispositivo, sendo 18,2% usuários atuais. O uso esteve associado à faixa etária mais jovem, ao consumo de álcool e ao uso de drogas ilícitas. A maioria percebe o cigarro eletrônico como comum no cotidiano e 92,7% acredita que ele causa dependência. A mídia informal foi a principal fonte de informação, evidenciando vulnerabilidade à desinformação. Conclui-se que ações de Promoção da Saúde como educação crítica, comunicação qualificada e criação de ambientes universitários saudáveis são fundamentais para reduzir riscos, fortalecer a autonomia dos estudantes e prevenir o uso precoce desses dispositivos.

Palavras-chave: Cigarros Eletrônicos. Estudantes. Promoção da Saúde. Comportamento de Risco. Mídias Sociais. Dependência de Nicotina.

RESUMEN

La promoción de la salud desempeña un papel fundamental en la comprensión y el abordaje del creciente uso de cigarrillos electrónicos entre estudiantes universitarios, especialmente dada la influencia de los medios digitales y la normalización social de estos dispositivos. El uso de cigarrillos electrónicos ha aumentado entre jóvenes y adultos, impulsado por ideas erróneas sobre su menor riesgo y la amplia difusión de información no cualificada. Este estudio tuvo como objetivo analizar el uso y el conocimiento sobre cigarrillos electrónicos entre estudiantes universitarios y evaluar cómo la promoción de la salud puede transformar este panorama. La investigación se llevó a cabo en 2024 con 275 estudiantes mediante un cuestionario estructurado en línea. Los resultados mostraron que el 36% ya había utilizado el dispositivo, y el 18,2% eran usuarios actuales. El uso se asoció con grupos de edad más jóvenes, consumo de alcohol y consumo de drogas ilícitas. La mayoría percibe los cigarrillos electrónicos como algo común en la vida diaria, y el 92,7% cree que causan adicción. Los medios informales fueron la principal fuente de información, lo que pone de manifiesto la vulnerabilidad a la desinformación. Se concluye que las acciones de promoción de la salud, como la educación crítica, la comunicación cualificada y la creación de entornos universitarios saludables, son fundamentales para reducir los riesgos, fortalecer la autonomía estudiantil y prevenir el uso temprano de estos dispositivos.

Palabras clave: Cigarrillos Electrónicos. Estudiantes. Promoción de la Salud. Conducta de Riesgo. Redes Sociales. Dependencia de la Nicotina.

1 INTRODUCTION

Tobacco use has been described since early times, with reports prior to 1000 B.C. Tobacco, like nicotine, has historically been associated with a sacred symbology, being consumed in religious rituals and even in a therapeutic way (RÄSÄNEN et al., 2020; TALHOUT et al., 2011).

Chinese pharmacist Ron Lik was the one who launched the electronic cigarette (EC), motivated by personal reasons: his father had died of lung cancer and he himself was an active smoker. To try to solve his smoking, he developed and patented the device. There are previous descriptions of similar inventions, but without wide dissemination or patent (KHALIL et al., 2022).

The EC, known by various names, such as "vape", e-cigarette, vaporizer, pod, pen drive, among others, is a technological innovation that allows the user to inhale aerosols produced by the vaporization of a battery-heated liquid, which is contained in the device. This inhalable aerosol is obtained through this vaporization of the liquid, and in this liquid it contains nicotine, flavorings, propylene glycol/glycerin, among other substances. Because of these and other substances, the EC is potentially harmful to health, as there is no legislation or standardization in Brazil on what to put in each device, thus making its use harmful (TRAVIS et al., 2023).

Regarding the legality of the EC, different countries adopt different approaches to the control of electronic cigarettes. In Brazil, the National Health Surveillance Agency (ANVISA) maintains the prohibition on the commercialization, importation, and advertising of these devices, based on the absence of conclusive evidence on their safety and efficacy as a smoking cessation tool (FIOCRUZ, 2024).

In contrast, about 80 countries around the world have regulated the sale of e-cigarettes (WHO, 2023). Despite the Brazilian ban in force since 2009, research points to a significant growth in use, especially among young people. The national prevalence was 0.64% in the general population in 2019 (SOUZA; SILVA; ALMEIDA, 2021), reaching 7.4% among individuals aged 18 to 24 years (INCA, 2023). Recent reports indicate that consumption quadrupled between 2018 and 2022 (CNN BRASIL, 2023), reaching the highest level ever recorded in 2024, with about 2.6% of adults using these devices, whose acquisition occurs easily through websites and digital platforms, even in the face of the ban. When doing an internet search about the device, Google itself indicates the places closest to you from which you can purchase the CE (INFOMONEY, 2024).

Adaptation to the FB was more expressive among adolescents and young adults. In 2014, in the United States, the use of EC exceeded that of conventional cigarettes (CC). In

2019, more than ten million American adults and three million adolescents used the device (CHAD et al., 2020). The risks of FB in this population are still under investigation, since this group was the one that showed the greatest increase in use.

It was only from 2018 onwards that more robust studies on the harms of the EC emerged. As it is a recent technology, many users use it without fully knowing the harm, believing that the EC reduces the harm associated with conventional cigarettes (HART NETT et al., 2020).

National studies, such as the one by Souza et al. (2021), demonstrate that the use of electronic smoking devices has increased significantly in Brazil, being more prevalent among young adults and associated with risk behaviors, such as the consumption of alcohol and other licit and illicit substances. Similarly, Costa et al. (2021) showed a high prevalence of use among medical students, highlighting a paradox between the level of theoretical knowledge and the practice of consumption, showing that knowledge is not influencing the practice of EC consumption.

Contemporary literature highlights the role of digital media and social networks in the dissemination of information, often misleading, about e-cigarettes. Evidence shows that pro-vape content published on digital platforms reduces risk perception and increases the likelihood of experimentation among adolescents and young adults (RUTHERFORD et al., 2023).

According to Fiocruz (2024), digital marketing strategies, influencers, and sponsored publications contribute significantly to the construction of the idea that these devices are less harmful, favoring their social normalization. Recent reviews also point out that the modern aesthetics of vapes, associated with a strong presence on social networks, reinforces their acceptance as a technological and socially desirable product, expanding early experimentation and continued use (BEZERRA; PINHEIRO, 2025).

This relationship between the use of electronic cigarettes and social, cultural, and media factors reinforces the need for health promotion strategies focused on the topic, especially in the educational environment (SILVA et al., 2021). With health promotion, an essential framework appears to understand and intervene in the use of electronic cigarettes among university students, articulating educational actions, regulation of digital advertising, strengthening of public policies and creation of academic environments that favor healthy choices.

The 2030 Agenda, adopted by the United Nations, establishes global goals that dialogue directly with the control of the use of these devices through the Sustainable Development Goals (SDGs).

SDG 3 — Good Health and Well-Being — includes targets related to strengthening the Framework Convention on Tobacco Control and preventing the use of psychoactive substances.

SDG 4 — Quality Education — is related to the development of personal skills and critical thinking to deal with misinformation, an aspect directly linked to this study. SDG 10 — Reduction of Inequalities — addresses access to reliable information on health risks, which is relevant given the scarcity of qualified information on the EC. SDG 12 — Sustainable Consumption and Production — includes the environmental impacts of improper disposal of electronic devices, remembering that the EC contains a battery inside. Thus, the use of electronic cigarettes requires intersectoral, sustainable actions aligned with global health goals (FIOCRUZ, 2024; BEZERRA; PINHEIRO, 2025).

In view of the above, the objective of the present study is to identify the use and knowledge about electronic cigarettes among university students, and how health promotion can act in this scenario.

2 MATERIALS AND METHODS

2.1 RESEARCH DESIGN AND ETHICAL ASPECTS

The research was approved by the Research Ethics Committee (CEP) of the University of Franca/SP under opinion No. 7,475,254, and the ethical aspects were determined by Resolution 466/12 of the National Health Council, safeguarding ethical rights in research with human beings.

This is a quantitative, cross-sectional and analytical study, carried out with university students from a private institution in the interior of São Paulo. The sampling was non-probabilistic by convenience, composed of students approached in person after the tests.

The collection took place in June 2025 and included students from the first to the sixth grade. A total of 275 students participated, a number corresponding to those who agreed to answer the questionnaire.

2.2 DATA COLLECTION

A structured questionnaire was applied online to university students. The students were approached at the University and invited to participate in the research. After accepting, the Informed Consent Form (ICF) was presented and then access to the online questionnaire was made available through a QR code. The sample consisted of 275 university students.

2.3 DATA PROCESSING AND STATISTICAL ANALYSIS

The data were initially organized in an electronic spreadsheet (Microsoft Excel®) and later exported to the Python® software (version 3.11) for statistical analysis.

The independent variables — gender, age group, year of course, self-reported ethnicity, alcohol consumption, and illicit drug use — were submitted to descriptive analysis, with absolute and relative frequencies. The distributions were represented by simple and stacked tables and bar graphs.

To investigate associations between the use of electronic cigarettes (current user, former user and never user) and the independent variables, appropriate statistical tests were applied for categorical variables. Pearson's chi-square test (χ^2) was used as the main procedure, adopting a significance level of 5% ($p < 0.05$). In situations with reduced expected frequencies, Fisher's exact test was used. The magnitude of the associations was evaluated using Cramer's V, interpreted according to the criteria: weak ($V < 0.10$), moderate ($0.10 \leq V < 0.30$) and strong ($V \geq 0.30$).

For ordinal variables, such as age group, the linear trend test was additionally applied. The variables perception of dependence, perception of how common the use is, time of first contact with the electronic cigarette and source of knowledge about the device were also analyzed. The results were presented in contingency tables, stacked bar graphs, and values of χ^2 , degrees of freedom, p value, and Cramer's V.

3 RESULTS

3.1 SOCIODEMOGRAPHIC PROFILE OF THE PARTICIPANTS

The sample consisted of 275 university students, predominantly female (70%). The most frequent age group was 18 to 25 years (82.3%). Most participants declared themselves white (82.8%). Regarding substance use, 76.3% reported current consumption of alcoholic beverages and 80.1% stated that they did not use illicit drugs. Table 1 with the sociodemographic characteristics of the participants is shown below.

Table 1

Sociodemographic characteristics of the participants

Variables	n	%
Gender		
Women	193	70,0
Male	82	30,0
Age group		
18–25 years old	226	82,3
26–35 years old	41	15,0
36–50 years old	8	2,6
Ethnicity		
White	228	82,8
Brown	43	15,7
Other	4	1,5
Alcohol use		

Current Usage	210	76,3
Never used	44	15,9
Former user	21	7,8
Illicit drug use		
Do not use	220	80,1
Current Usage	18	6,4
Past Use	37	13,5

Source: The authors.

3.2 USE OF ELECTRONIC CIGARETTES AND ASSOCIATED VARIABLES

When asked about the use of electronic cigarettes, most students had never used electronic cigarettes (63.9%). Among those who have already used it, 18.2% were current users and 17.2% were former users. The use of the device showed a significant association with age, alcohol consumption, and illicit drug use. Below is table 2 with the numbers of participants who are users or non-users.

Table 2

Use of electronic cigarettes among participants

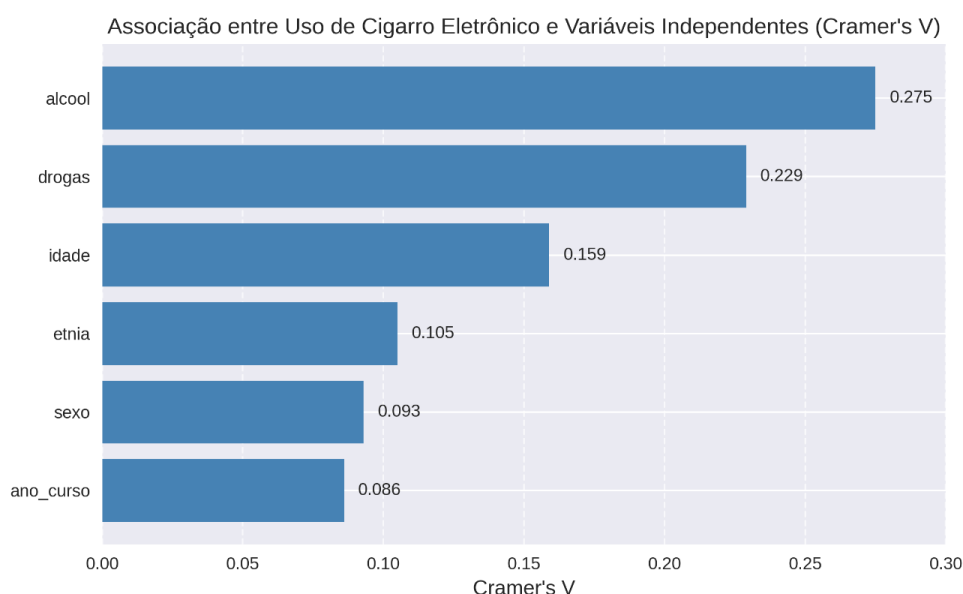
Category	n	%
Never used	176	63,9
Current user	50	18,2
Former user	47	17,2
Sporadic use	2	<1

Source: The authors.

The graph below shows that only age, alcohol consumption, and illicit drug use were significantly associated with the use of e-cigarettes, with higher magnitudes for alcohol ($V = 0.275$) and drugs ($V = 0.229$). Indicating that drinking behavior is strongly related to the use of the device, similarly, to the use of illicit drugs. Gender, year of the course and ethnicity did not show relevant associations, indicating that behavioral factors explain the pattern of use better than demographic characteristics.

Figure 1

Associations between independent variables and e-cigarette use



Source: Authors.

3.3 FREQUENCY OF USE, FIRST CONTACT, AND PERCEPTIONS

Among users, 47.3% reported use at specific times and 22.8% daily use. The first contact occurred mostly before college (42.3%). It was also evaluated how common the participants evaluate the use of the EC. The perception of prevalence showed that 47.2% consider it common in everyday life and 33.1% common at parties. The distribution of the answers shows that most students perceive the use of electronic cigarettes as common or common at parties, while a smaller portion considers it uncommon or says they do not use it. These data indicate that use is largely normalized in the student environment.

The perception of dependence was high among the participants, with 92.7% stating that electronic cigarettes cause dependence, while only 2.5% answered that they did not and 4.7% did not know how to inform.

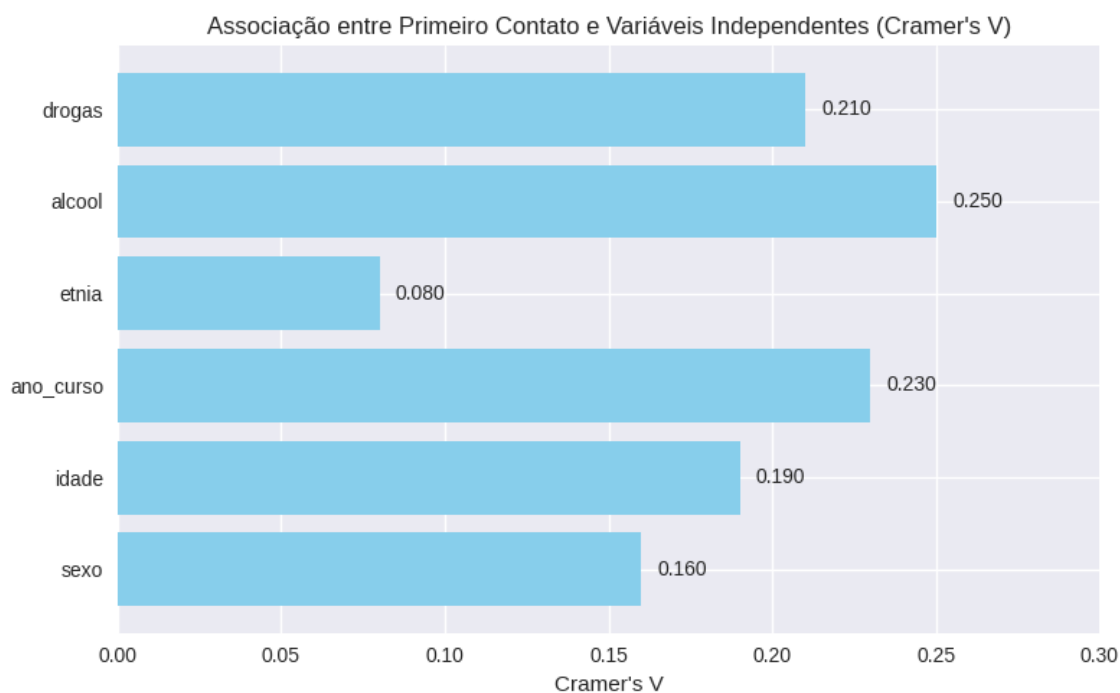
The relationship between the moment of first contact and the current use profile shows that the use of electronic cigarettes is concentrated among those who had already tried the device, especially before college. Individuals who have never had contact do not appear among current users, reinforcing the consistency of the data. This distribution is consistent with the associations observed in the Cramer's V graph, which indicate a greater relationship between the first contact and behavioral factors — such as alcohol consumption ($V = 0.25$) and the use of other drugs ($V = 0.21$) — and with academic characteristics, such as the year of the course

($V = 0.23$). In contrast, sociodemographic variables such as sex and ethnicity showed weak and non-significant associations.

In general, the findings suggest that the first contact with electronic cigarettes is more linked to risk contexts and associated behaviors than to demographic characteristics, once again.

Figure 2

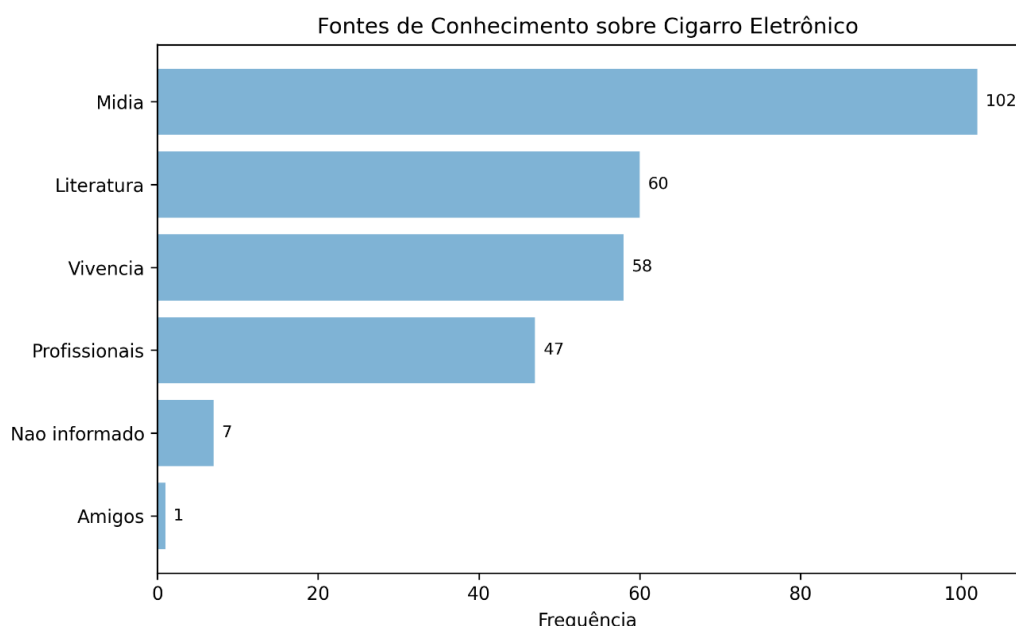
Moment of first contact with the electronic cigarette



Source: Authors.

3.4 SOURCES OF INFORMATION AND INFERENTIAL ANALYSIS

Informal media was the main source of knowledge (38.1%), followed by scientific literature (22.4%) and personal experience. The absolute and relative frequencies of each category are shown in figure 3 below, also showing the visual distribution of these proportions.

Figure 3*Distribution of knowledge sources*

Source: Authors.

The inferential analyses showed that informal media was associated with a higher prevalence of use and perception of normalization. The predominance of the media suggests that digital content exerts a strong influence on the formation of perceptions on the subject, although formal sources — such as scientific literature and health professionals — also contribute to students' knowledge.

In the inferential analysis, only the consumption of alcoholic beverages showed a significant association with the source of knowledge ($\chi^2 = 91.77$; gl = 35; $p < 0.001$; $V = 0.26$), indicating distinct patterns between consumers and non-consumers. The variables sex, age, year of course, ethnicity, and use of illicit drugs did not show significant associations.

When relating the source of knowledge with other main variables, an association was observed with the moment of first contact with electronic cigarettes ($\chi^2 = 32.06$; gl = 15; $p = 0.006$; $V = 0.20$) and with the perception of how common the use is ($\chi^2 = 44.48$; gl = 20; $p = 0.001$; $V = 0.20$). Students who perceive the use as more frequent tend to base their knowledge on the media or personal experiences. Another strong association occurred with the perception of dependence ($\chi^2 = 72.99$; gl = 10; $p < 0.001$; $V = 0.36$), and those who are informed by scientific literature or health professionals showed greater recognition of the potential for dependence. There was no significant association between the source of knowledge and the profile of use ($\chi^2 = 7.78$; gl = 5; $p = 0.169$; $V = 0.17$).

It is concluded that the type of source consulted mainly influences perceptions and exposure patterns, and not general sociodemographic or behavioral characteristics, as well as all the other results above.

4 DISCUSSION

The results of this study show a complex and multifactorial scenario in relation to the use and knowledge of electronic cigarettes among university students. Most of the survey participants were female (70%), which corroborates a national trend already described in official surveys. According to the 2010 Demographic Census, released by the Brazilian Institute of Geography and Statistics (IBGE), women represent the majority of enrollments in Brazilian higher education, which reinforces the greater female presence also in surveys carried out in this educational context (IBGE, 2012).

Thus, the composition of the sample of this study not only reflects the local reality, but also aligns with the national panorama of feminization of higher education. Similar results were found by Costa et al. (2020), who identified 50.5% of women among the participants of their research, with a mean age of 22.9 years — an age group very close to that observed in the present study. This pattern was also reported by Oliveira et al. (2020), in an investigation carried out in the state of Piauí, where 61.5% of the respondents were female. These findings reinforce that the greater participation of women in research with university students is not an isolated phenomenon, but rather a consistent trend in different regions of the country.

The literature suggests that this female predominance may be related not only to the greater entry of women into higher education, but also to a greater willingness of women to participate in academic research and activities related to health and education (COSTA et al., 2020; OLIVEIRA et al., 2020). Thus, the composition of the sample of this study is in line with national and regional evidence, giving robustness and representativeness to the results obtained.

Although the majority of study participants were female, e-cigarette users were predominantly male. This finding is in line with the results of Pereira et al. (2023), Malta et al. (2022), Bertoni and Szklo (2021) who also identified a higher prevalence of use among men.

Although most participants had never used the device (63.9%), it was observed that more than one third of the sample had already had contact with the EC, with 18.2% current users and 17.2% former users. These findings reinforce the growing trend observed in national and international studies, which point to an increase in the use of e-cigarettes among young adults, even in contexts where their sale is prohibited (SOUZA et al., 2021; FIOCRUZ, 2024).

In a University Center in Piauí, it was found that 51.18% of the participants had already used electronic cigarettes at least once, while 48.81% had never used them. This result differs from that observed in the present study, in which most students (63.9%) reported never having used the device. Also in this same study, 14.17% of the participants were classified as former users and 25% as sporadic users of electronic cigarettes, already on these data corroborate with the current study. (VARGAS et al., 2021).

The significant association between the use of FBs and the younger age group confirms the vulnerability of this group, which has already been described in the literature. Research shows that adolescents and young adults are more susceptible to experimenting with new nicotine consumption technologies, influenced by social, aesthetic, and media factors (RUTHERFORD et al., 2023; BEZERRA; PINHEIRO, 2025).

In the present study, this vulnerability is also expressed in the fact that 42.3% of the participants had their first contact with the EC even before entering the university, indicating early exposure and possible influence of previous social environments.

As observed in the present study, in which the majority of e-cigarette users are in the age group of 18 to 25 years, Bertoni et al. (2021) and Souto et al. (2022) also identified this age group as the main consumer of these devices in their research.

Another relevant finding was the moderate association between the use of FBs and the consumption of alcohol and illicit drugs. This pattern is widely documented in the literature and suggests that the use of electronic cigarettes is part of a broader set of risk behaviors (COSTA et al., 2021).

The simultaneous presence of these practices reinforces the need for integrated prevention strategies that consider the social and behavioral context of young people, and not just the device itself. Souza et al. (2021) also evidenced the relationship between the use of FBs and alcohol or other drugs. Still on this association of alcohol and drug consumption related to the use of EC, a study carried out at the University Center of Araguari showed that 37.17% of users use alcohol or some type of drug (PEREIRA et al., 2023).

The students' perception of the use of the EC also deserves to be highlighted. Most consider the use common in everyday life (47.2%) or at parties and weekends (33.1%), which indicates social normalization of the device. The association between informal media and higher prevalence of use can be explained by continuous exposure to content that minimizes risks, reinforces the modern aesthetics of devices, and normalizes their consumption. This informational environment creates a reinforcement cycle, in which the perception of common use increases the probability of experimentation, especially among young people who already

have risk behaviors, such as the consumption of alcohol and other drugs. This phenomenon is largely influenced by the modern aesthetics of vapes, the strong presence on social networks, and the circulation of content that minimizes their risks (RUTHERFORD et al., 2023).

Pereira et al. (2023) identified that 32.05% of the participants were e-cigarette users. Among these, 3.84% reported daily use of the device and 7.69% stated that they used it only at specific times, findings that corroborate the results observed in the present study.

In the same sense, the fact that 38.1% of the participants stated that they learned about the EC through informal media reinforces the central role of digital platforms in the construction of perceptions and behaviors. Glasser et al. (2017) highlight that knowledge about electronic cigarettes among young people and adults tends to be heterogeneous, varying according to personal experiences, access to information, and exposure to the media. This finding is similar to the results of the present study, in which diversity was also observed in the perceptions and level of understanding of students about the risks and characteristics of the device.

Similarly, Alves et al. (2024) identified that, although many participants claim to have some knowledge about electronic cigarettes, most of them have doubts about the safety and potential harms associated with use. The authors point out that this ambiguous perception may favor experimentation, especially among young people who believe that the device is less harmful than conventional cigarettes. In the study by Alves et al. (2024), the interviewees demonstrated that they recognized some risks, but still underestimated important aspects related to dependence and long-term effects, a pattern that was also reflected in the findings of this study.

Despite this normalization, 92.7% of students believe that electronic cigarettes are addictive. This data reveals an important paradox: knowledge about the risks has not been enough to reduce use, a phenomenon also observed in studies with health students (COSTA et al., 2021). This mismatch between knowing and doing shows that information alone is not capable of modifying behaviors, reinforcing the need for broader approaches, such as those proposed by Health Promotion.

Porfírio et al. (2025) also identified an important gap in users' knowledge about electronic cigarettes, highlighting that many of them have only superficial information or information based on misperceptions. The authors emphasize that this lack of adequate understanding of the risks and mechanisms of operation of the device contributes to the maintenance of experimentation behaviors and continuous use, especially among young people.

In a complementary way, FIOCRUZ (2024) demonstrated in its studies the direct influence of digital media in the construction of perceptions about electronic cigarettes.

According to the institution, content disseminated on social networks — often produced by influencers, brands or ordinary users — tends to minimize risks, reinforce the idea of modernity and present the device as a "safer" alternative to conventional cigarettes. This constant exposure to information that has not been scientifically validated contributes to the formation of distorted beliefs, which is in line with the findings of the present study, in which a large part of the students reported obtaining information about electronic cigarettes through informal means.

These data dialogue directly with the need for structured interventions, with the principles of Health Promotion, which emphasize the strengthening of personal skills, the creation of healthy environments and the regulation of external factors that influence individual choices. The predominance of informal media as a source of information, for example, points to the urgency of media literacy and health communication strategies aimed at young people.

Likewise, the association with alcohol and drugs suggests the need for integrated interventions that consider the social and cultural context in which the use of the EC is inserted.

In addition, the results are in line with the goals of the 2030 Agenda, especially SDG 3 (Health and Well-being), which includes actions to prevent the use of psychoactive substances and strengthen tobacco control policies. SDG 4 (Quality Education) is also related to the development of critical thinking and skills to deal with misinformation — aspects directly implicated in the way students know and interpret electronic cigarettes. SDG 12 (Sustainable Consumption and Production) highlights the need to pay attention to the environmental impacts of the improper disposal of electronic devices, a topic that is still little discussed, but relevant in the face of the popularization of disposable vapes.

Thus, the results of this study reinforce that the use of electronic cigarettes among university students cannot be understood only as an individual choice, but as a phenomenon influenced by social, cultural, media and behavioral determinants, demonstrating that the use of electronic cigarettes among university students is determined mainly by informational and behavioral factors, rather than by sociodemographic characteristics.

Health Promotion emerges, therefore, as an essential way to transform this scenario, offering strategies that go beyond information and that seek to change contexts, strengthen public policies and promote environments that favor healthier choices, aligning with the goals of the SDGs and the contemporary demands of health prevention.

5 CONCLUSION

The present study allowed us to understand the knowledge, use, and perceptions about electronic cigarettes among university students, revealing a relevant panorama for public health

and professional training. A predominance of female participants and young adults was observed, a profile that follows the national trend of feminization of higher education, as described by the IBGE and recent studies. This finding reinforces the representativeness of the sample and the coherence of the results with the literature.

Although most students do not use electronic cigarettes, it was identified that a significant portion has already tried or currently uses the device, usually in social contexts. Among users, occasional use predominated, but cases of frequent use were also reported, indicating potential for dependence. In addition, it was found that many students have incomplete or mistaken information about electronic cigarettes.

Another relevant aspect was the finding that most students obtain information about electronic cigarettes through informal sources, such as social networks and personal experiences. This scenario highlights a gap in academic training, especially in health courses, which should offer up-to-date content based on scientific evidence.

In view of these findings, the central role of Health Promotion stands out, confirming that it can transform this scenario. By adopting a broadened, critical and educational approach, Health Promotion can act in the construction of healthier university environments, in the strengthening of student autonomy and in the dissemination of qualified information. Institutional strategies, such as educational campaigns, conversation circles, inclusion of the topic in the curriculum and permanent prevention actions, can contribute to reducing vulnerabilities, combating misinformation and promoting more conscious choices.

Despite its contributions, like any study, this one also has limitations. Even so, the findings offer important subsidies for the planning of interventions and point to paths for future research, such as longitudinal studies, comparative analyses between courses and evaluations of the effectiveness of Health Promotion actions in the university environment.

It is concluded that electronic cigarettes represent an emerging challenge among university students, requiring consistent and continuous educational responses. Integrating Health Promotion into institutional practices is essential to expand knowledge, strengthen protective behaviors and contribute to the training of professionals who are better prepared to guide the population and face the risks associated with the use of these devices.

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THE IMPORTANCE OF CORPORATE GOVERNANCE FOR THE VALUATION OF A STARTUP

A IMPORTÂNCIA DA GOVERNANÇA CORPORATIVA PARA A VALORAÇÃO DE UMA STARTUP

LA IMPORTANCIA DEL GOBIERNO CORPORATIVO PARA LA VALORACIÓN DE UNA STARTUP



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ABSTRACT

This article aims to identify and analyze organizational practices related to Corporate Governance adopted in startups. Concepts of Corporate Governance and Startups in the context of the market are presented in order to better understand models of startup management. The analyses carried out on strategies and organizational practices adopted to manage governance strategies in startups are based on these theories and also on primary data from research conducted with managers and employees of startups, using a qualitative approach and a form through Google Forms. The results point to the existence of advantages and disadvantages obtained through the adoption of startup management models. It was concluded that startups have greater agility in their management, facilitating the realization of transformations and adaptations of the business model, but could benefit from a professionalization of the corporate governance area, as well as the adoption of compliance practices, documentation, and standardization of their processes to ensure decision-making processes and investment capture.

Keywords: *Startups*. Corporate Governance. *Compliance*. Code of Ethics. Organizational Values. Innovation.

RESUMO

O presente artigo possui por finalidade identificar e analisar práticas organizacionais relativas à Governança Corporativa adotadas em startups. São apresentados conceitos de governança corporativa e Startups no contexto do mercado, para que se possa melhor compreender modelos de administração de startups. As análises realizadas acerca de estratégias e práticas organizacionais adotadas para gerir as estratégias de governança em *startups* tomam como base estas teorias e, também, dados primários provenientes de pesquisas realizadas com gestores e funcionários de startups, por meio da abordagem

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qualitativa, utilizando de um formulário via *Google Forms*. Os resultados apontam para a existência de vantagens e desvantagens obtidas por meio da adoção de modelos de gestão de startups. Concluiu-se que as Startups possuem maior agilidade em sua gestão, facilitando a realização de transformações e adaptações do modelo de negócio, porém poderiam vir a se beneficiar de uma profissionalização da área de governança corporativa, bem como da adoção de práticas de *compliance*, documentalização e padronização de seus processos para assegurar os processos decisórios e captação de investimentos.

Palavras-chave: *Startups*. Governança Corporativa. *Compliance*. Código de Ética. Valores Organizacionais. Inovação.

RESUMEN

Este artículo tiene como objetivo identificar y analizar las prácticas organizacionales relacionadas con el gobierno corporativo adoptadas en startups. Se presentan conceptos de gobierno corporativo y startups en el contexto del mercado para comprender mejor los modelos de gestión de startups. El análisis de las estrategias y prácticas organizacionales adoptadas para gestionar las estrategias de gobierno en startups se basa en estas teorías y también en datos primarios de una investigación realizada con gerentes y empleados de startups, utilizando un enfoque cualitativo y un cuestionario de *Google Forms*. Los resultados señalan la existencia de ventajas y desventajas derivadas de la adopción de modelos de gestión de startups. Se concluyó que las startups poseen mayor agilidad en su gestión, lo que facilita las transformaciones y adaptaciones del modelo de negocio, pero podrían beneficiarse de una profesionalización del área de gobierno corporativo, así como de la adopción de prácticas de cumplimiento, documentación y estandarización de sus procesos para garantizar la toma de decisiones y la captación de inversiones.

Palabras clave: *Startups*. Gobierno Corporativo. *Compliance*. Código de Ética. Valores Organizacionales. Innovación.

1 INTRODUCTION

With the popularization and growth of startups in the Brazilian market, it was observed the absence of knowledge on the part of entrepreneurs about the necessary structuring to preserve the sustainability of the business, whether these are legal or even strategic management structures.

Despite its innovative nature, the mortality rate among startups is also a reality, and in some cases they are even higher than conventional micro and small companies (NOGUEIRA et al., 2014).

One of the biggest problems for new startups is going through the early stages of founding and stabilizing themselves in the market. After her conception, she goes through some stages of development, which can lead her to grow or die. Many startups die as a result of the results related to the launch of the product, its demand and lack of investment. In addition to the low familiarity of the creators with business management, and especially with the company's corporate governance. (ALVES, 2013).

The solution to many of these problems is the application of corporate governance methodologies in these new companies. Many of the large companies today have efficient governance programs, keeping them in the market. It is difficult to find a literature applied exclusively to the governance of startups.

It is seen today that most entrepreneurs have advanced technical knowledge, capable of creating an innovative product with high potential. However, these same entrepreneurs do not have in-depth knowledge directed to the management of their businesses. Among several needs, we can mention the use of a business model, in order to assist in the organization of the startup that will provide good governance and a possibility of more sustainable growth.

Due to the great growth in the number of startups in Brazil and in the world, it is important to study topics related to them, seeking to better understand their aspects, characteristics and phenomena, so that one can contribute to the academic environment and in the performance of professionals in the areas of administration or even managers of organizations that have not formally carried out studies in this area.

The study of startups has growing importance not only in the economic scenario, but also in the academic scenario, due to the increase in the number of companies based on this model. Investments in startups reached a record \$9.4 billion in Brazil in 2021, a growth of almost 170% compared to the previous year, according to data from Distrito. Worldwide, venture capital contributions reached the figure of US\$ 643 billion, up 92%, according to Crunchbase (Available at: www.crunchbase.com/search/organization.companies).

Considering this context, this study intends to address the importance of corporate governance for the valuation of a Startup, as a way to mitigate the risks that emerge from the lack of organizational structuring practiced in the innovative ecosystem.

To this end, the objective was to describe the peculiar context in which Startups are found and their relationship with management tools.

In addition, this study intends to verify the degree of alignment of corporate governance tools for startups, considering their particular characteristics as innovative companies, as a way to provide more security to stakeholders, through risk control.

It is also intended to evaluate the resistance to the formalization of processes within Startups when they are contextualized in a volatile and innovative environment. To this end, a field research was carried out with managers and employees in order to compare the results proposed as the objective of this study, understanding their views on the aspects of corporate governance in startups.

Thus, the following work is structured as follows: The first part proposes to contextualize and conceptualize the terms of Startups and Corporate Governance. In the second part, research methodologies and data analysis will be addressed. For the third part, we will have the results presented and discussions followed by the final considerations.

2 THEORETICAL FOUNDATION

2.1 CONCEPTUALIZATION OF STARTUPS

Throughout the history of management, as new organizational theories have been created, the emergence of the term "startup" is noticeable, a key factor in this article. When it comes to the conceptualization of startups, one can find several definitions. According to Eric Ries (2012), a startup is a human institution designed to create a new product or service under conditions of extreme uncertainty.

Nagamatsu et. AL (2014) states that in order to understand the concept of startup, it is necessary to verify the degree of innovation involved in the enterprise and the creation of new business models, considering the history of successful commercialization, as well as the transformations of the segment in which a given organization is inserted.

For Gitahy (2010), despite the existence of several concepts, the most current one, defended by him, represents a startup as a group of people looking for a repeatable and scalable business model, working in conditions of extreme uncertainty.

Feigelson et al. (2018) understand that startups have an innovative profile in relation to traditional market dynamics and, therefore, aim to provide experiences, through products and services, that are innovative.

In addition, startups generally do not distribute profits as traditional companies and corporations do, since they make their best efforts (and values are included) to revert to the performance of the product or service developed (FEIGELSON et al. 2018).

They reduce investments in personnel and operations, largely involving each founder, usually using the so-called Bootstrapping³.

Nybo (2016) explains that Bootstrapping can be done in two ways: "(i) minimizing the need for financing by obtaining resources at low cost; and (ii) acquisition of funds without the intervention of banks or financing through the disposition of equity interest". Thus, costs are reduced in search of development without a high mobilization of resources.

Because they operate with low resources in areas that exceed the investment required for the development of the product or service, they create a simple structure, which contains only what is necessary for such development, which is called MVP – Minimum Viable Product (translated by the authors as Minimum Viable Product) (FEIGELSON et al. 2018).

In addition, startups are distinguished from companies in the traditional market by their proximity to the world of technology. Generally, the product or service is developed and made available through digital platforms or other forms of technology (FEIGELSON et al. 2018).

The forms of investment are traditionally defined by the binomial debt versus equity. Feigelson et al. (2018) indicate that in debt investment, the creditor contributes values envisioning a future return on the return of the amount, with monetary adjustment, interest and other agreed penalties. In capital investment, the creditor is interested in participating in the business, which will be operated through the conversion of this investment into portions of the invested company.

The Legal Framework for Startups and Innovative Entrepreneurship – Complementary Law No. 182/2021 institutionalized six instruments, already in use in the market: a) stock or quota subscription option agreement entered into between the investor and the company; b) stock or quota option agreement; c) convertible debenture; d) loan agreement convertible into equity interest; e) a partnership in a participation account; and f) angel investment contract.

³ Bootstrapping – "the act of tying or fastening the boot", which is nothing more than the contribution of the founders' own resources in the constitution of the company (ASSOCIAÇÃO BRASILEIRA DE STARTUPS, 2017; FEIGELSON et al., 2018).

2.2 CORPORATE GOVERNANCE AND INTERNAL CONTROLS

As seen earlier, there are several ways for investors to enter startups. In any choice, it is up to the investor to weigh the risks and benefits that may come with the decision. To facilitate the analysis of the investor and other stakeholders, there are tools that provide some predictability to some shares of the invested company. These tools, together, make up corporate governance, which will be the object of study in this part.

2.2.1 Concepts of Corporate Governance and Its Pillars

There are several definitions for corporate governance. The Brazilian Securities and Exchange Commission (CVM) defines it as:

A set of practices that aims to optimize a company's performance by protecting all stakeholders, such as investors, employees, and creditors, facilitating access to capital.

Nelson Siffert Filho (1998) defines it synthetically as the way in which the controlling shareholders institute monitoring and control mechanisms in relation to the managers and make them act in accordance with the interest of the controlling shareholders (in a broader view, stakeholders). Durval Noronha Goyos Jr. (2003) defines it as a continuous and organized effort by shareholders and executives to achieve the best possible alignment of interests.

The Brazilian Institute of Corporate Governance (2015) defines corporate governance as a system, supported by institutional arrangements that direct, monitor and encourage the operation of business companies and organizations, regulating the structure and behavior of partners, managers and employees, as well as their interconnection with external entities and stakeholders.

Also according to the Brazilian Institute of Corporate Governance (2015), in order to fulfill such functions, corporate governance is supported by four guiding principles: accountability; Disclosure; fairness; and corporate responsibility (compliance), which are described below:

- a) As for the first principle, it is extremely important that the company develops and institutionalizes a culture of accountability, involving its shareholders and partners, but, mainly, its managers. It must occur in a clear and understandable manner, based on accounting practices (ROSSETTI; ANDRADE, 2014).
- b) Transparency, on the other hand, is a vector of trust between the external and internal members of the company, in addition to being a great differential in its image. For this reason, there must be a culture of "wanting to inform" and not "having to inform", not only focusing on results and financial destinations, but also on operations and policies, so that there is an effective creation

of value, as taught by Álvares et al. (2008). This, of course, within the limits of what is strategically possible to be shared, safeguarding the interests of the company.

- c) Equity, in turn, is based on the assumption of equal treatment of all shareholders or partners, and of other interested parties, prohibiting, in any case, discriminatory policies (ÁLVARES et al., 2008). And to this end, the "rights, duties, needs, interests and expectations" of these stakeholders must be taken into account (INSTITUTO BRASILEIRO DE GOVERNANÇA CORPORATIVA, 2015).
- d) Finally, corporate responsibility has an important function, which is to keep the company in compliance with current standards, not only to national legislation, but also to the constitutive and regulatory acts of the company itself (ROSSETTI; ANDRADE, 2014).

2.2.2 The Brazilian Corporate Governance Model

Andrade and Rossetti (2014) consider that the historical, cultural, economic and institutional profile of each country are the factors that influence the corporate governance models to be practiced. These models are grouped into shareholder⁴, which is specifically aimed at shareholders, and stakeholder,⁵ which is more comprehensive; in addition to the interests of shareholders, the interests of internal and external audiences are also considered.

According to the IBGC (2015), Corporate Governance systems are divided into two main models: Outsider System⁶ and Insider System⁷.

In Brazil, we see elements of both corporate governance models. Initially, it is seen that investments and financing are mostly operated via debt, since the capital market has not yet reached a significant level in the country. However, there has been a growth in relation to external sources of investment and private equity funds, as pointed out by Rossetti and Andrade (2014).

However, even with a large concentration of capital stock in a few shareholders or partners, Brazil follows a shareholder-oriented logic, as seen in the Anglo-Saxon model. This is because companies value achieving the interests of shareholders at all costs, which causes some problems to arise in the short term. And so, according to Álvares et al.:

By prioritizing the pursuit of shareholder value, companies are less concerned with other issues, such as pollution or child labor. In other words, the focus on shareholder value

⁴ Shareholders are often also characterized by being investors in the company.

⁵ Stakeholders are a group or people that affect the company, and combine direct or indirect, positive and negative interests in the obligation to manage: management, planning and execution of projects.

⁶ Outsider System: shareholders are pulverized and typically outside the daily command of the organization's operations;

⁷ Insider System: Large shareholders typically in charge of daily operations directly or via people of their appointment

disregards the issues of other stakeholders. Such a focus can prevent executives from acting differently, even when there is a clear moral issue. The response to stakeholders would only be valid when there was a threat to the company's reputation (2008, p. 34).

2.3 CORPORATE GOVERNANCE TOOLS

Corporate governance, as seen, is composed of tools and procedures that ensure security and predictability in the company's management, reducing risks and impacts in the short and medium term. Next, some tools usually used to confer control to the management of companies will be analyzed.

2.3.1 Decision Control Tools

Decision-making control tools are those instituted through bodies in society and that have the function of determining scales for decision-making, especially those that interfere in the course of business. Some of them will be covered below. (SANTA CRUZ, 2019).

The Board of Directors is a corporate body, constituted either as a limited liability company or a corporation, and in publicly traded companies, companies with authorized capital and in mixed-capital companies, its incorporation is mandatory. It is one of the pillars of corporate governance, along with the Executive Board and the Owners, and is characterized by being a deliberative, unique and plural body, whose objective is to accelerate and decentralize the decision-making process, especially with regard to decisions about business management (SANTA CRUZ, 2019).

The Executive Board, as the name implies, is the executive body of the corporation or limited liability company. The executive members are responsible for directing the company and, externally, representing it. This function, it should be noted, cannot be performed by any other corporate body, as it is its exclusive competence, under the terms of article 138, paragraph 1, of Brazilian Corporation Law 18 (COELHO, 2019).

2.3.2 Compliance Tools

Compliance tools are those responsible for verifying the adequacy of the company's practices to current standards, whether external or internal to the organization. They align the expectation with the reality of the business, in order to avoid complications resulting from unlawful acts, such as fines and other sanctions.

In a more grounded way, compliance is a set of rules, standards, ethical and legal procedures, which, once defined and implemented, will be the main line that will guide the

behavior of the institution in the market in which it operates, as well as the attitude of its employees (CANDELORO; RIZZO; PINHO, 2012).

For Ribeiro and Diniz (2015), the importance of compliance originates precisely from a demand from shareholders and stakeholders for ethical and transparent practices in the conduct of business or government activities.

Clayton (2013) goes further, as he argues that managers and directors perceive compliance as an investment, and not as a cost, simply because the rules and procedures that are part of the program's policies can prevent errors and help identify possible fraud.

But compliance is not a mere compliance with rules, formal or informal, since, in fact, it is a specific policy that, once defined, should be the line that will guide the performance in its segment (RIBEIRO AND DINIZ, 2015).

Therefore, there is a need for even more efficient and firm transparency and ethics policies in companies. Control must involve a well-defined policy, and it is important to consider that this is a process under construction, where changes are possible as long as they are within a plausible demand (MAEDA, 2013).

2.3.3 The Code of Ethics or Conduct Tool

The code of conduct is responsible for institutionalizing ethical standards and principles, aligned with the company's values, which reflect the company's identity and culture, with responsibility and respect, as well as social and environmental concerns. It must be based on the principles of corporate governance, mainly to encourage transparency and compliance, both to internal and external policies (INSTITUTO BRASILEIRO DE GOVERNANÇA CORPORATIVA, 2015).

The company's management must define the levels of applicability of the code, but must bear in mind its own submission to the rules set out in it. This is because the code of conduct is the maximum representation of the commitment of managers, shareholders and employees to the company's culture and values, always aiming at joint, healthy growth and risk mitigation (INSTITUTO BRASILEIRO DE GOVERNANÇA CORPORATIVA, 2015).

Therefore, the Code of Conduct does not intend to limit the company's performance or place it in a non-competitive role compared to its competitors, on the contrary, the rules of conduct make the organization place itself responsibly in the market, restricting the impacts to itself. After all, the code does not need to regulate only the internal relationships, but also the way in which suppliers, customers and even investors (AZEVEDO, 2010). However, it should be noted that the mere institution of a Code of Conduct is not enough to bring the

positive returns that are sought. It is necessary to effectively consolidate an ethical culture in the company.

3 METHODOLOGY

The characteristics of the procedures that were adopted for the data collection stages are described here, as well as the profile of the company and the participating interviewees

A descriptive case study, where the reports, analyses and conclusions that were exposed are based on data from an exploratory field research, bibliographic, through the use of a qualitative approach, and based on primary data. This is considered exploratory, as it aims to obtain greater familiarity with the problem, making it more explicit (GIL, 2007).

This is a qualitative research, since it focuses on obtaining an in-depth understanding of the theme (GOLDENBERG, 1997). According to Minayo (1993), research typified as qualitative seeks to understand values, beliefs, representations, habits, attitudes and opinions, deepening the complexity of phenomena, facts and processes.

3.1 DESCRIPTION OF THE OBJECT OF STUDY

There were three Startups participating in the research (for confidentiality purposes, they will be identified in this article as Startups A, B and C), with physical headquarters located in São Paulo and Santa Catarina, with their employees distributed throughout the rest of the country working remotely (including Manaus/AM). All of them have been in operation for less than 3 years and operate in the information and communication technology sector. The participating organizations have small teams, with a range of at least 15 and a maximum of 30 employees.

These organizations can be characterized as startups, and not just small early-stage companies, due to the presence of characteristics presented in the theoretical foundation, such as uncertainty, repeatability and scalability present in their business models and ways of operating. They were chosen to participate in the present research, therefore, due to these characteristics, in addition to the accessibility criterion.

3.2 DATA COLLECTION INSTRUMENT

In order to obtain the largest amount of different information possible, and with a high degree of detail, structured surveys were carried out via Google Forms with managers and employees of the Startup in action addressing the subject in focus, applied from January to February 2023.

3.2.1 Construction of the instrument structure

A base questionnaire was used to conduct the research, which was constructed and divided into two similar audiences: for managers and for employees. according to guidelines on the general context of the company, so that the panorama of the organization under study can be understood.

- a) Questions 1 to 13 referred to the general context of the company, so that the panorama of the organization and the employee/manager can be understood.
- b) Questions 14 to 16 were fictitious situations about how the interviewee would position himself in his view as a manager/employee in the pillars of this case study: Code of Conduct, Compliance and Decision Control.
- c) Questions 17 to 21 questioned the employee/manager's view of governance aspects within their organization. If these are clearly communicated and followed and how they are aligned between managers and employees.

3.3 DATA ANALYSIS PROCEDURE

Based on the answers sent by the managers and employees of startups interviewed and on the previously exposed literature, comparisons, discussions and conclusions were made about characteristics related to corporate governance in startups.

At first, content analysis procedures were used, adopting three stages: exploratory phase; data collection phase; and data analysis phase, performing interpretations and inferences based on the data collected. (MINAYO, 1998).

For the analysis of the collected data, the method suggested by Fontanella et al. (2011) was also used, which consists of using the following procedural steps: make the raw data records available; immerse yourself in each record; compile the analyses; gather the themes of each category; name the data; and allocate them to a table.

4 PRESENTATION AND DISCUSSION OF RESULTS

4.1 ASPECTS OF THE FUNCTIONAL STRUCTURE OF STARTUPS

The startups participating in this research have a lean structure and have a small team. It is also possible to verify a predominantly horizontal structure, with more informal relationships between different positions than those held in conventional organizations. The relationship between the manager and the team is much closer, with direct communication regarding various issues. As described in the form by one of Startup X's employees:

"Here at Startup X, teams don't necessarily need to have all their decisions approved by the CEO or someone who occupies a higher position. We have greater decision-making

autonomy and self-management. But if necessary, we use communication via WhatsApp, which makes access to managers in the area even faster." (Startup X Collaborator)

In this way, it is noticeable that startups have greater agility in carrying out their processes, presenting a lower level of bureaucratic impediments that could lead to an increase in the time needed to complete tasks or even change organizational practices used. However, it is clear that strategic decisions to be made by the manager have the support and opinion of employees due to this functioning of the structure. This perception is evident in the report sent by the manager of Startup Y:

Everything here happens very fast, we don't have lengthy processes that will end up delaying our business and development. All decisions about the company have the participation of the entire team, everything is communicated and open to opinions. (Startup Manager Y)

4.2 ASPECTS OF CORPORATE GOVERNANCE AND DISSEMINATION OF STRATEGIC MANAGEMENT TOOLS

Table 1

Aspects of Corporate Governance and alignment of Organizational Culture

Existence of code Ethics/Conduct/Compliance.			Information about Mission, Vision, Values and Year of the company's foundation.	
Startup	Employees	Manager	Employees	Manager
X	Yes	Yes	They knew how to respond partially	They knew Reply
Y	No	No	They did not know how to answer	They knew Reply
Z	No	No	They did not know how to answer	They knew Reply

Source: Prepared by the authors

According to Table 1, it can be seen that, in general, the startups analyzed have informally defined corporate governance processes, not having documentation or formal establishment of standardized procedures to be adopted in relation to their posture internally or externally when representing the company. None of the participating companies has a formally established corporate governance area.

Although Startup X responds positively about having a code of conduct, this is initially applied in the employee's service contract, as described by one of the managers: "When signing the contract with us, there are clauses that will explain the guidelines on the employee's posture in relation to their activities in the company." (Startup Manager X)

For Tenório (2015), informality and the absence of written rules and procedures bring greater agility to the management of the organization, however, it makes management difficult as the activities to be performed by employees are not clearly and precisely defined. In this way, slowness in processes can occur, due to situations in which it is not known who is responsible for a certain task or posture to be adopted.

This characteristic can bring greater agility in management in the short term. However, it can also generate negative results in the medium and long term for the organization, due to the absence of formally established procedures for verifying results.

In the view of the managers, some differences in the nature of the organizational practices of the startups analyzed are perceived when compared to the views of the employees. This perception is evident when we compare the answers about the Startup's Mission, Vision and Values in Table 1.

There is an indication, therefore, that, generally, corporate governance in the context of startups is more dynamic and less formally structured. This ends up not being clearly propagated and is focused on maintaining an organizational environment favorable to the team's conduct and performance of daily activities, even if implicitly. In the following sections, the corporate governance practices verified in startups are analyzed according to categories of activity.

4.3 STRATEGIC MANAGEMENT TOOLS ADOPTED

4.3.1 Code of Ethics/Conduct

Table 2

Question: Do you believe that the guidelines on how to proceed in moral and delicate situations are extremely clear in your company?

Startup	Employees	Manager
X	Partially clear	Extremely clear
Y	Partially clear	Extremely clear
Z	Are not clear	Partially clear

Source: Prepared by the authors.

Through the analysis of the interviewees' answers, it can be seen that the formulation of organizational practices and strategies related to corporate governance in the startups in focus is carried out based on the managers' perception with regard to organizational performance, performance of tasks and eventual problems faced. According to the answer of one of the employees of Startup Z:

We know how to behave, it's the "common sense" in our startup. However, it was never formally written and presented. As situations arise, we talk internally and make a decision on how to act on it. (Startup Z Collaborator)

Therefore, the instruction of ethical conduct is usually carried out as new needs are perceived by the managers themselves.

It can be seen, therefore, that it is a process of continuous improvement, being defined by Gozzi (2015) as one that does not take as its main objective the realization of significant changes, but a gradual process with constant changes.

Therefore, the Code of Conduct does not intend to limit the company's performance or place it in a non-competitive role compared to its competitors, on the contrary, the rules of conduct make the organization place itself responsibly in the market, restricting the impacts to itself. After all, the code does not only need to regulate internal relationships, but also the way in which suppliers, customers and even investors are treated (AZEVEDO, 2010). However, it should be noted that the mere institution of a Code of Conduct is not enough to bring the positive returns that are sought. It is necessary to effectively consolidate an ethical culture in the company.

To date, managers have indicated that the use of this strategy of informal formulation of the code of ethics has been sufficient to meet the needs presented and manage the organization. As described by the manager of Startup Y:

We really don't have a formal, complete code of conduct for everyone. However, to date, all moral and ethical situations have been circumvented and resolved internally. (Startup Manager Y)

However, as presented in Table 2, the employees indicated that the guidelines on how to proceed in moral and delicate situations are not extremely clear. It can be suggested that planning carried out in order to structure, professionalize and document organizational practices of corporate governance could be responsible for avoiding any problems that may arise as the number of employees in the startup increases, or even as their turnover occurs.

4.3.2 Compliance

Table 3

Question: Do you believe that, in case of harassment, you would know who to look for to report?

Startup	Employees	Manager
X	I would know who to look for	They would know exactly who to look for
Y	I'm not sure I'd know who Search	I don't know if they would know who to look for
Z	I'm not sure I'd know who Search	I don't know if they would know who to look for

Source: Prepared by the authors

According to comparisons in Table 3 in Startups, Compliance tools are not formally described to employees. Not all employees would know how to proceed in case of harassment, for example.

According to Ribeiro and Diniz (2015), they state that compliance can be applied to any type of company, regardless of its segment. What needs to be very well analyzed are the characteristics of the company. In other words, what needs to be very well studied are the reality and culture of each company, because the format applied in an organization, even if similar to a company, cannot be imposed. Even because its success depends on the commitment of all.

The lack of these formalized guidelines for everyone in the company can lead to legal or ethical problems internally and externally.

The implementation of a Compliance program is directly up to the leadership, which must play its role by demonstrating attitudes that really seek to adopt ethics and integrity as company philosophies, respecting all loyal and social norms and rules. It must also count on the dedication of the entire team, so that they can know the risks to which the Startup is exposed and will define how to carry out its activities in a safer, more professional and honest way.

4.3.3 Decision-making control

Table 4

Question: Are the approval and decision-making flows well aligned for you?

Startup	Employees	Manager
X	Yes, they are well aligned	Yes, they are well aligned
Y	Are partially aligned	Yes, they are well aligned
Z	Are partially aligned	Yes, they are well aligned

Source: Prepared by the authors

In the participating Startups, the horizontality and proximity of interpersonal relationships between different positions is illustrated, demonstrating how professional relationships in startups tend to be less guided by the hierarchy conventionally adopted in traditional organizations. According to the answer of one of the employees of Startup X:

Here we don't see the founders as our superiors, they are people like us participating in the day-to-day and activities. They are accessible and we can talk to them directly whenever we need to. (Startup X Collaborator)

This factor can be positive, as it makes employees feel like an integral part of the company, also working in a friendlier and more relaxed environment. However, attention should be paid to behavioral issues that may be presented by employees who understand the relaxation present in the startup environment as a pretext for non-compliance with rules or their functions.

The answers in Table 4 of the managers in comparison to the collaborators lead to the conclusion that the explicitness of the flow of decision-making control consists, therefore, in informal structuring, and it is considered important that the employees act as a united and communicative team, thus knowing who is responsible for the decision, but not establishing standard documents, manuals or procedures.

Thus, greater dynamism and ease of adaptation can be obtained in the field of structuring the company, a relevant characteristic for the proper functioning of startups, operating in markets that are constantly changing.

However, due to these characteristics, communication failures and problems resulting from them may occur, due to the lack of formalization. This factor can represent serious risks to the longevity of the organization, since the absence of formalization of processes and planning can culminate in bad results for the company, such as communication failure, inconsistency in decision-making. Therefore, the need to document and manage organizational knowledge and practices in startups is perceived.

4.4 THE IMPORTANCE OF CORPORATE GOVERNANCE IN STARTUPS

Through the answers of the interviewees presented earlier in this article, it can be seen that corporate governance is not emphasized in startups, since there is no formalization of most practices or even continuous improvement processes, and this information is considered tacit knowledge among managers and members of organizations. They are generally treated as the responsibility of the manager responsible for carrying out a certain task.

In order to adopt corporate governance strategies, however, it is necessary for the organization to undergo changes in processes, structures, information systems and individual and collective incentives (Terra, 2005). It is, therefore, a relatively complex implementation change, as it depends directly on the change of several factors of a given organization.

Despite the wide demand for agility in carrying out processes in startups, the lack of formalization of processes can lead to managerial problems. It is necessary to formalize the activities to be carried out in the company to disconnect a position from its occupant. For Weber (1982), commercial management is increasingly based on precision, constancy and, above all, speed of operation. In order to achieve these criteria, the organization must be bureaucratized, relying on control tools.

The position must be disassociated with its occupant and have the description of activities and conducts formalized, aiming to facilitate the relationship between employee, employer and supplier, as the attributions and responsibilities of a given position and its conducts are defined (FRANCO, 2007).

Therefore, the implementation of corporate governance practices in startups would be of great use, as they would professionalize management and increase the formal documentation of processes, conducts, and organizational practices in the context of startups. In this way, they would ensure the maintenance of technical knowledge acquired through previous experience and results, reducing the need for rework or even incurring errors already made in the company's history. By adopting such measures, one can therefore expect better organizational results and increased organizational effectiveness.

5 FINAL CONSIDERATIONS

This study aimed to address the importance of corporate governance for the valuation of a Startup, as a way to mitigate the risks that emerge from the lack of organizational structuring practiced in the innovative ecosystem, providing more security to stakeholders, among which investors stand out.

Through the discussions presented, it is concluded that corporate governance is important in startups, and it is possible to contribute to the expansion of the theoretical structure that existed until then when it comes to the subject of corporate governance in the context of startups.

Having analyzed the results of the research carried out, it is clear that these startups present, albeit informally, a basic knowledge about corporate governance tools. In the context of the companies analyzed, it is found that, despite presenting a certain degree of misalignment

between the guidelines of conduct, there are good practices between managers and employees in the field of corporate governance. As well as about the general context of the organization. This development is due to the lack of action plans formally outlined and explained in documents, actions that could optimize the company's management and provide better future results.

There is some resistance to the bureaucratization and formalization of processes in startups, which, on the one hand, allows for greater agility in the transformation of processes, but can also imply the occurrence of failures in the processes and consequent generation of rework.

It is hoped, therefore, that the discussions and results in this article can help entrepreneurs who are in the process of starting new ventures. In addition to these conclusions, it can also be seen, as a result of the research, that conventional organizations in search of agile changes, which bring impacts in a shorter period of time, can be mirrored in management practices used in startups.

Finally, it is recommended that the valuation and credibility of the corporate governance area be investigated, in the context of startups from other sectors, from the perspective of managers and employees, thus obtaining parameters of comparison with the results currently reported here. To consolidate new information about Startups.

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REAL ESTATE REGISTRY VERSUS PUBLIC DOMAIN: HOW FAR DOES REGISTRY PRESUMPTION EXTEND IN COASTAL FEDERAL LANDS?

REGISTRO IMOBILIÁRIO VERSUS DOMÍNIO PÚBLICO: ATÉ ONDE VAI A PRESUNÇÃO REGISTRAL DIANTE DOS TERRENOS DE MARINHA?

REGISTRO DE LA PROPIEDAD INMOBILIARIA FRENTE AL DOMINIO PÚBLICO: ¿HASTA DÓNDE LLEGA LA PRESUNCIÓN DE REGISTRO EN RELACIÓN CON LOS TERRENOS MARÍTIMOS?



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ABSTRACT

This article examines the legal framework governing coastal federal lands (*terrenos de marinha*) and their implications for the real estate registry system, focusing on the registrar's role when public ownership is not reflected in the property record. It is based on the hypothesis that such lands belong to the Federal Government by constitutional determination, with original ownership independent of registration, thus limiting the presumption of registry legitimacy. The study adopts a qualitative, doctrinal legal methodology, grounded in statutory analysis, specialized doctrine, and case law from the Brazilian Superior Court of Justice. It addresses the requirement of the Transfer Authorization Certificate (CAT), the relative nature of registry presumption, and the limits of legal qualification. The article concludes that requiring prior regularization before federal authorities does not constitute undue innovation, but rather reflects the registrar's legal duty to ensure continuity, legality, and legal certainty within the registry system.

Keywords: Real Estate Registry. Coastal Federal Lands. Public Property. Transfer Authorization Certificate (CAT). Legal Qualification.

RESUMO

O presente artigo analisa o regime jurídico dos terrenos de marinha e seus acréscidos e suas implicações no registro de imóveis, com enfoque na atuação do registrador diante da incidência de domínio público não refletido na matrícula. Parte-se da hipótese de que tais bens integram o patrimônio da União por determinação constitucional, sendo sua titularidade originária e independente de registro, o que limita a presunção de legitimidade do fôlio real. A pesquisa adota metodologia qualitativa, de natureza jurídico-dogmática, com base na análise da legislação, da doutrina registral e da jurisprudência do Superior Tribunal de Justiça. Examina-se a exigência da Certidão Autorizativa de Transferência (CAT), a

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relatividade da presunção registral e os limites da qualificação registral. Conclui-se que a exigência de regularização perante a União não configura inovação, mas expressão do dever legal do registrador de assegurar a continuidade, a legalidade e a segurança jurídica do sistema registral.

Palavras-chave: Registro de Imóveis. Terrenos de Marinha. Domínio Público. Certidão Autorizativa de Transferência (CAT). Qualificação Registral.

RESUMEN

Este artículo analiza el régimen jurídico de los terrenos marítimos y sus acreciones, así como sus implicaciones para el registro de la propiedad, centrándose en el papel del registrador ante el dominio público no reflejado en el registro. Parte de la hipótesis de que dichos bienes forman parte del patrimonio de la Unión por mandato constitucional, siendo su titularidad original e independiente del registro, lo que limita la presunción de legitimidad del folio inmobiliario. La investigación adopta una metodología cualitativa, de carácter jurídico-dogmático, basada en el análisis de la legislación, la doctrina registral y la jurisprudencia del Tribunal Superior de Justicia. Se examinan el requisito del Certificado de Autorización de Transferencia (CAT), la relatividad de la presunción registral y los límites de la calificación registral. Se concluye que el requisito de regularización ante la Unión no constituye una innovación, sino una expresión del deber jurídico del registrador de garantizar la continuidad, la legalidad y la seguridad jurídica del sistema registral.

Palabras clave: Registro de la Propiedad. Terrenos Marítimos. Dominio Público. Certificado de Autorización de Transferencia (CAT). Calificación Registral.

1 INTRODUCTION

The Brazilian real estate registry system occupies a central position in the legal organization of property, playing an essential role in the stabilization of property relations and in the promotion of legal certainty. Its normative structure, based on principles such as publicity, continuity and specialty, gives the real estate registry a presumption of legitimacy, making it an element of trust in economic relations and an instrument for the realization of the constitutional economic order.

However, that presumption is not absolute. On the contrary, it is compatible with the incidence of special legal regimes, especially those related to public goods, whose constitutional and legal discipline imposes limits on private autonomy and the free circulation of property.

The relevance of this discussion becomes even more evident when considering the Brazilian scenario of land and registry irregularity. According to data from the Brazilian Institute of Geography and Statistics, approximately 50% of urban properties in Brazil have some type of ownership or registration irregularity, either due to lack of registration or document inconsistency (IBGE, 2019). In the same sense, the National Council of Justice, through diagnoses carried out within the scope of the national land regularization policy, points out that more than 30 million properties in the country are in an irregular situation, which represents a significant portion of the national urban territory (CNJ, 2021).

This picture reveals a profound dissociation between the factual reality and the registry reality, compromising the function of the registry as an instrument of legal certainty. Technical studies by the Real Estate Registry Institute of Brazil reinforce that the lack of correspondence between the real folio and the effective legal situation of the property is one of the main factors of fragility of the Brazilian registry system, directly affecting the reliability of real estate transactions.

The importance of this debate can also be understood in the light of international approaches to the relationship between ownership, formalization, and economic development. Hernando de Soto (2000) demonstrates that the absence of adequate formalization of property rights compromises the ability to circulate wealth and limits access to credit, converting assets into "dead capital". This perspective shows that the disconnection between the legal reality and the registry reality is not a mere technical problem, but a structural factor of economic inefficiency, reinforcing the need for rigorous action by the registry system in correcting these asymmetries.

In the specific context of federal public goods, the problem takes on even more sensitive contours, especially in view of the extension of the Brazilian coast, which exceeds 7,367

kilometers of coastline, according to official data from the IBGE, along which numerous properties potentially subject to the legal regime of marine land and its additions are located. Despite this territorial coverage, the existence of real estate registrations that do not reflect this legal condition is recurrent, either due to the absence of annotation or due to the historical lag of the records.

In this scenario, a situation of apparent registration regularity is formed, in which private domain chains develop over decades without any mention of the dominiality of the Union. This phenomenon can be understood in the light of the theory of systemic risk of real estate registration, according to which the accumulation of uncorrected inconsistencies compromises the reliability of the system as a whole, generating diffuse legal uncertainty and potentiating conflicts between different legal regimes.

It is in this context that the central problem of the present study is inserted: what should be the posture of the real estate registrar when asked to perform a registration act on a property whose registration does not indicate the incidence of a public legal regime, but on which formal administrative information falls — from the Secretariat of Federal Heritage — in the sense of whether it is marine land or added?

The issue involves the tension between two structuring vectors of the legal system: on the one hand, the legal certainty derived from the presumption of legitimacy of the registration; on the other, the supremacy of the public domain, whose existence does not depend on inscription in the royal folio. It is, therefore, a matter of investigating to what extent the registrar should stick to the content of the registration and to what extent should he consider extra-registration elements, especially those coming from a competent administrative authority.

From this perspective, the registrar's role plays a decisive role in containing systemic risks and preserving the coherence of the legal system. As the registry doctrine highlights, the registration of real estate cannot be understood as a static reality, but as a dynamic instrument for adapting legal advertising to the normative reality (DIP, 2016). Thus, the registration qualification must be exercised in such a way as to prevent the entry of titles incompatible with the legal system, even if formally regular in light of the content of the registration.

The analysis of this problem requires, therefore, the investigation of the role of the registrar in the exercise of registration qualification, the delimitation of the limits of its performance in the face of official information and the understanding of the real estate registry as a mechanism of articulation between legal certainty, legality and protection of public assets.

In view of this scenario, it is hypothesized that the action of the real estate registrar, by requiring the regularization of the legal situation of the property before the Federal Heritage

Secretariat and the presentation of the Transfer Authorization Certificate (CAT), does not constitute an undue innovation in the registration qualification, but an expression of the legal duty to control legality and preserve legal certainty. The general objective of the present study is to analyze the limits of the presumption of legitimacy of the real estate registry in the face of the incidence of the public domain, especially with regard to marine land and its additions. As specific objectives, it seeks to: (i) examine the legal regime of these assets and their independence in relation to the real estate registry; (ii) analyze the function and limits of registration qualification in the face of extra-registration administrative information; and (iii) to assess the legitimacy of the requirement of regularization before the Federal Government as a condition for the entry of the title in the royal folio. The research adopts a qualitative methodology, of a legal-dogmatic nature, developed through the systematic analysis of the applicable legislation, the specialized doctrine and the jurisprudence of the higher courts, with emphasis on the integrated interpretation of the rules that govern the real estate registry law and the legal regime of public assets. The present research is justified by the practical and theoretical relevance of the theme, considering the high number of properties in irregular situation in Brazil, the extension of the coastal strip subject to the Federal Government's property regime and the systemic risks arising from the dissociation between the legal reality and the registry reality.

2 THE LEGAL REGIME OF NAVY LAND AND ITS IMPLICATIONS IN THE REAL ESTATE REGISTRY

The analysis of the legal regime of navy land and its additions reveals one of the most complex intersections between public and private law within the scope of the Brazilian real estate registry system. It is a legal category that, although often inserted in formally registered private domain chains, is subject to its own constitutional and legal regime, whose incidence does not depend on registration in the royal folio, imposing limits on registration and the circulation of property.

Under the terms of article 20, item VII of the Federal Constitution of 1988, navy lands and their additions constitute assets of the Union, subject to a legal regime of a public nature, characterized by unavailability, the supremacy of the public interest and the need for specific administrative control. Law No. 9,636/1998, when disciplining the matter, establishes that the incorporation of these assets into the Federal Government's assets results from a proper administrative procedure, whose nature is declaratory, and not constitutive, so that the public domain does not depend on real estate registration for its existence or effectiveness.

This characteristic projects direct effects on the registry system, insofar as it evidences the insufficiency of registration as the only parameter for defining the legal ownership of the property, requiring the registrar to act beyond the merely formal analysis of the real folio, to consider the incidence of duly proven special legal regimes.

2.1 THE REQUIREMENT OF THE TRANSFER AUTHORIZATION CERTIFICATE (CAT) AND THE ADMINISTRATIVE CONTROL OF REAL ESTATE CIRCULATION

The transfer of rights over real estate located on navy land is subject to specific administrative control, under the terms of article 33, paragraph 2 of Law No. 9,636/1998, which conditions the practice of these acts to the prior authorization of the Federal Heritage Secretariat, formalized through the issuance of the Transfer Authorization Certificate – CAT.

The CAT is an essential instrument for controlling the circulation of these assets, attesting to the regularity of the legal and fiscal situation of the property before the Federal Government, especially regarding the payment of *laudemium*, the absence of debts related to the forum or occupancy tax and the regularity of the occupation. Its requirement is not presented as a faculty of the registrar, but as an objective legal imposition, linked to the legal regime of public goods.

In this context, the absence of the CAT prevents the entry of the title in the real estate registry, not because of excessive formalism, but because it makes it impossible for the Federal Government to control its assets, in direct affront to the principle of unavailability of public assets. The registrar's action, in requiring such a document, is, therefore, an expression of the duty of legality and an instrument for preserving the integrity of the legal system.

2.2 THE RELATIVITY OF THE REGISTRY PRESUMPTION IN THE PUBLIC DOMAIN

The presumption of legitimacy of the real estate registry, enshrined in article 1,245 of the Brazilian Civil Code, is a structuring element of legal certainty in the context of private relations. However, such presumption has a relative nature (*juris tantum*), referring exclusively to what is formally registered in the registration, and does not extend to legal situations not reflected in the actual folio.

In this sense, the incidence of the public domain, duly proven by a formal administrative act, is not ruled out by the absence of registration in the registration, nor by the existence of an apparently regular private domain chain. The jurisprudence of the Superior Court of Justice is firm in recognizing that the public domain is not subject to the logic of private real estate registration, and can be affirmed regardless of registration

It is important to highlight that, in this context, the existence of private rights is not denied, but rather the recognition that such rights are legally limited by the incidence of a public regime, which imposes the necessary adaptation of the registration to the legal reality of the asset.

2.3 THE EXTRINSIC ANALYSIS OF THE TITLE AND THE LIMITS OF THE REGISTRAR'S PERFORMANCE

The registration activity has an administrative nature, under the terms of article 1 of Law No. 8,935/1994, and is materialized through registration qualification, which consists of controlling the legality of the titles presented.

This qualification is limited to the extrinsic analysis of the title, including the verification of its formal regularity, the capacity of the parties, compatibility with the registration system and compliance with the legal system. It is not up to the registrar to exercise a jurisdictional function or settle complex technical or domain controversies, especially when there is a conflict between administrative documents.

In the face of divergent information, such as the coexistence of administrative certificates and a formal letter from the SPU indicating the public nature of the property, the registrar must adopt a posture of caution, demanding the regularization of the situation before the competent body, instead of opting for one of the versions, under penalty of exceeding the limits of its action.

2.4 THE LACK OF NEED FOR PRIOR REGISTRATION AND THE NEED TO ADAPT THE ROYAL FOLIO

The characterization of the property as navy land does not depend on prior registration in the registration, since the administrative demarcation has its own legal effectiveness. Requiring such registration as a condition for the application of the legal regime would imply subverting the logic of the system, subordinating the public domain to the real estate registry.

However, once the legal nature of the asset is verified, the necessary updating of the real folio is required, through an annotation that reflects this reality, in compliance with the principle of objective specialty, provided for in article 176 of Law No. 6,015/1973.

In this way, the requirement formulated by the registrar not only enables the practice of the registration act in accordance with the law, but also ensures the adequate representation of the legal reality of the property in the registry.

2.5 THE PREVALENCE OF THE PUBLIC INTEREST AND THE PROTECTION OF THE FEDERAL GOVERNMENT'S ASSETS

The legal regime of navy land is a direct expression of the principle of unavailability of public assets, according to which the assets of the Union cannot be freely alienated or encumbered without observing the legal requirements.

The requirement of authorization from the SPU and the presentation of the CAT is an indispensable control mechanism for the preservation of this patrimony, being widely recognized by the jurisprudence of the Superior Courts as a condition for the validity of the transfer acts.

In this context, the registrar's performance, in demanding compliance with these requirements, not only observes legality, but plays a fundamental role in protecting public assets and maintaining the coherence of the legal system.

3 THE REGISTRAR'S POSTURE IN THE FACE OF THE INCIDENCE OF THE LEGAL REGIME OF NAVY LANDS

The performance of the real estate registrar, in the context of the incidence of the legal regime of navy land and its additions, reveals itself as a turning point between the legal security of registration and the supremacy of the public interest. This is a situation in which the exercise of registration qualification ceases to be a mere formal activity to assume a decisive character in the preservation of the legality, continuity and coherence of the legal system.

In the face of titles formally eligible for registration, but which fall on real estate whose legal nature is changed by suitable administrative information – especially from the Secretariat of Federal Heritage – the registrar is required to adopt a technical, reasoned and legally responsible posture, guided not only by the content of the real folio, but by the legal system in its entirety.

3.1 THE DUTY OF REGISTRATION QUALIFICATION IN THE FACE OF OFFICIAL INFORMATION FROM THE PUBLIC ADMINISTRATION

The argument according to which the absence of annotation in the registration would rule out the incidence of the legal regime of navy lands is not supported in the light of registry dogmatics. The real estate registry enjoys a presumption of legitimacy, but not absoluteness, being a relative presumption (*juris tantum*), which can be removed by proof to the contrary from a competent authority.

In this context, the formal communication of the Secretariat of Federal Heritage – based on a regularly approved administrative demarcation procedure – constitutes a relevant legal

element and capable of directly influencing the registration qualification. This is not mere opinion information, but a technical statement from the body responsible for the management of federal Sunday assets.

Thus, the registrar not only can, but must consider such information in the exercise of its function, under penalty of violation of the principle of legality. The registration qualification is not limited to the static reading of the registration, but involves a true judgment of legality, aimed at preventing the entry of titles incompatible with the current legal system.

3.2 THE ABSENCE OF UNDUE INNOVATION IN THE REGISTRATION QUALIFICATION

The allegation that the requirement formulated by the registrar would constitute an undue innovation in the registration qualification is not valid. On the contrary, it is a legal response to a new and relevant fact, communicated by a competent public authority, which changes the understanding of the legal situation of the property.

The absence of prior registration in the registration does not prevent the recognition of the public nature of the property, especially when proven by a formal administrative act. The jurisprudence of the Superior Court of Justice is firm in the sense that navy lands are assets of the Union regardless of registration, since their ownership derives directly from the Federal Constitution.

In this sense, the registrar's performance does not constitute innovation, but adaptation of the registration to the legal reality, avoiding the perpetuation of inconsistencies in the system.

3.3 THE INSTITUTIONAL ROLE OF THE REGISTRAR AS AN AGENT OF LEGALITY CONTROL

The registration activity, under the terms of Law No. 8,935/1994, has an administrative nature and is subject to the principle of strict legality. The authors Cristiano Cassetari and Marcos Salomão (2025) explain that this constitutional principle, when applied to notary activities, means that all related acts must be based on the law, according to the formalities of the CF/88, especially its article 5, II. The registrar acts as a delegated agent of the public power, responsible for ensuring publicity, authenticity, security and effectiveness of legal acts.

In this context, the registration qualification constitutes a mechanism of preventive control of legality, intended to prevent the entry of titles incompatible with the legal system. As Ricardo Dip teaches, it is not a merely formal activity, but a true filter of legality, essential to the reliability of the registry system.

This institutional function is directly connected to article 170 of the Federal Constitution of 1988, insofar as the real estate registry acts as an instrument for the organization of property and the promotion of economic development, ensuring that the circulation of goods takes place in accordance with the law.

The role of the registrar as an agent of legality control can also be understood from the perspective of the economic analysis of the law. Guido Calabresi (1970), when examining the social costs of legal decisions, points out that efficient institutional structures are those capable of preventing conflicts and reducing systemic risks. In this sense, the registry qualification, by preventing the entry of titles incompatible with the legal system, acts as a preventive mechanism to reduce future social costs, avoiding litigation, invalidations and insecurity in property relations.

3.4 THE DUTY TO INSPECT TAXES AND CHARGES

The registrar's performance is not limited to verifying the formal validity of the titles, but also covers the control of the tax regularity of the acts presented. Pursuant to article 30, item XI of Law No. 8,935/1994, it is incumbent upon the delegate to supervise the payment of taxes levied on the acts he performs.

In the case of navy land, this duty is especially relevant, since the transfer of rights is conditioned to the payment of property charges due to the Federal Government, such as laudemium, forum and occupation tax. The Transfer Authorization Certificate (CAT) is an essential instrument for verifying this regularity.

Provision No. 149/2023 CNJ reinforces this obligation, by establishing that the registrar must refuse the entry of securities that do not meet the legal requirements, including tax and administrative regularity.

3.5 THE LIMITS OF REGISTRY ACTION AND THE IMPOSSIBILITY OF EXERCISING A JURISDICTIONAL FUNCTION

Registration qualification is limited to the extrinsic analysis of the title, including the verification of its formal aspects and its compatibility with the legal system. It is not up to the registrar to resolve complex technical or domain controversies, especially when there is a divergence between administrative documents.

In the face of conflicting information — such as certificates presented by interested parties and formal communication from the SPU — the registrar must adopt a posture of caution, demanding the regularization of the situation before the competent body. To act

otherwise would imply assuming a jurisdictional function, incompatible with the administrative nature of the registry activity.

3.6 THE LEGAL RISK OF THE PRACTICE OF THE ACT IN NON-COMPLIANCE WITH THE LEGAL REGIME

The requirement of compliance with the legal regime of public assets within the scope of real estate registration is also supported by the theory of regulation. Anthony Ogus (2004) argues that state intervention is justified in contexts of market failures, especially when there is information asymmetry or risk of negative externalities. In the case of navy lands, the absence of control over the circulation of these assets could generate relevant impacts not only on public property, but on the security of the registry system itself, legitimizing the registrar's role as an agent of normative enforcement.

Carrying out the registration without complying with the legal regime applicable to navy lands implies a serious legal risk, which may lead to the nullity of the act, the ineffectiveness of the transfer before the Federal Government and the liability of the delegate.

The jurisprudence of the Superior Court of Justice recognizes that legal transactions involving public goods without compliance with legal requirements are legally vulnerable, not producing full effects.

In this scenario, the registrar's action, by refusing the entry of an irregular title, not only observes legality, but acts as a mechanism to contain systemic risks and preserve legal certainty.

4 FINAL CONSIDERATIONS

The analysis developed throughout this study shows that the controversy involving the incidence of the legal regime of navy land in the scope of the real estate registry is not limited to a specific interpretative conflict, but reveals a structural tension between the presumption of legitimacy of the real folio and the supremacy of the public domain.

The position held by the private parties, in the sense that the absence of registration in the registration would remove the incidence of the legal regime of the Union's assets, is based on a premise incompatible with the Brazilian legal system. By attributing to the real estate registry a constitutive character of public domain, such an understanding disregards that the navy lands and their additions are assets of the Union by constitutional determination, whose ownership is original and does not depend on registration in the royal folio.

The administrative demarcation carried out by the Secretariat of Federal Heritage, in turn, has a declaratory nature, being sufficient to evidence the incidence of the public legal regime, even if such condition is not reflected in the registration. In this context, the presumption of legitimacy of the real estate registry, provided for in article 1,245 of the Civil Code, is relative, and cannot prevail in the face of suitable evidence to the contrary, especially when emanating from a competent administrative authority.

The registrar's performance, in this scenario, cannot be understood as a mere formal or mechanical activity. On the contrary, it constitutes an exercise of legality control, under the terms of article 1 of Law No. 8,935/1994, which imposes on the delegate the duty to ensure the publicity, authenticity, security and effectiveness of legal acts. This institutional function is projected as an instrument for the stabilization of legal relations and the realization of the right to property in accordance with the constitutional order.

Thus, the requirement to regularize the legal situation of the property before the Federal Heritage Secretariat, as well as the presentation of the Transfer Authorization Certificate – CAT, does not constitute an undue innovation in the registration qualification, but stems directly from the fulfillment of a legal duty. This is a necessary measure to ensure the compliance of the registry with the applicable legal regime, preserving the integrity of the registry system and avoiding the consolidation of legal situations incompatible with the public domain.

It is important to highlight that legal certainty, the main purpose of the registration system, is not to be confused with the immutability of the content of the registration, but with its correspondence to the legal reality. In this sense, the registrar's action, by conditioning the entry of the title to the fulfillment of legal requirements, does not violate the principles of continuity or legal certainty, but, on the contrary, concretizes them.

In addition, the duty to supervise the legality of the titles presented, which includes the verification of compliance with the legal and tax obligations levied on the acts, is an essential element of the registration activity. Failure to comply with these requirements would compromise not only the validity of the registration act, but also the reliability of the system as a whole, with direct impacts on the security of economic relations.

In this context, the real estate registry reaffirms its nature as an instrument for organizing property and promoting economic development, as recommended by article 170 of the Federal Constitution of 1988. Its performance, therefore, must be guided by legality, the protection of the public interest and the preservation of the coherence of the legal system.

It is thus concluded that the registrar's stance, in demanding the regularization of the situation of the property and compliance with the legal requirements for the entry of the title in

the real folio, is not only legally adequate, but necessary to maintain legal certainty, the protection of public assets and the integrity of the Brazilian real estate registry system.

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THE RELEVANCE OF INVENTORY MANAGEMENT IN THE SUPPLY CHAIN OF THE GRAIN PROCESSING MACHINERY AND EQUIPMENT INDUSTRY

A RELEVÂNCIA DA GESTÃO DE ESTOQUES NA CADEIA DE SUPRIMENTOS DA INDÚSTRIA DE MÁQUINAS E EQUIPAMENTOS PARA BENEFICIAMENTO DE CEREAIS

LA RELEVANCIA DE LA GESTIÓN DE INVENTARIOS EN LA CADENA DE SUMINISTRO DE LA INDUSTRIA DE MAQUINARIA Y EQUIPOS PARA EL PROCESAMIENTO DE CEREALES



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ABSTRACT

This article analyzes the relevance of inventory management in the supply chain of the grain processing machinery and equipment industry, focusing on its implications for operational efficiency. The research, theoretical in nature and with a descriptive-exploratory approach, was developed through a systematic literature review of books and specialized journals in the fields of logistics, operations management, and supply chain management. The study is structured around three topics: the inventory management methods and practices applied to the sector, the relationship between inventory control and the efficiency of logistics and production processes, and the role of inventory management in supply chain integration and performance. The results show that the adoption of more consistent inventory management practices, such as ABC classification, cycle counting, and safety stock management, significantly contributes to reducing operational costs, preventing supply disruptions, and ensuring the continuity of production processes within the supply chain. It is concluded that inventory management represents a strategic factor for competitiveness and improved performance in the sector in the face of uncertainties in the global market, recommending investments in technologies and collaborative practices with suppliers and distributors.

Keywords: Inventory Management. Supply Chain. Grain Processing. Operational Efficiency.

RESUMO

Este artigo analisa a relevância da gestão de estoques na cadeia de suprimentos da indústria de máquinas e equipamentos para beneficiamento de cereais, com foco em suas implicações para a eficiência operacional. A pesquisa, de natureza teórica e caráter descritivo-exploratório, foi desenvolvida por meio de revisão bibliográfica sistemática em obras e periódicos especializados nas áreas de logística, gestão de operações e gestão da cadeia de suprimentos. O estudo está estruturado em torno de três tópicos: os métodos e

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práticas de gestão de estoques aplicados ao setor, a relação entre o controle de inventário e a eficiência dos processos logísticos e produtivos, e o papel da gestão de estoques na integração e no desempenho da cadeia de suprimentos. Os resultados evidenciam que a adoção de práticas mais consistentes de gestão de estoques como classificação ABC, inventários cíclicos, e gestão do estoque de segurança, contribui significativamente para a redução de custos operacionais, de quebras no abastecimento e garantia da manutenção dos processos produtivos da cadeia. Conclui-se que a gestão de estoques representa um fator estratégico para a competitividade e um melhor desempenho do segmento diante das incertezas do mercado mundial, recomendando-se investimentos em tecnologias e em práticas colaborativas com fornecedores e distribuidores.

Palavras-chave: Gestão de Estoques. Cadeia de Suprimentos. Beneficiamento de Cereais. Eficiência Operacional.

RESUMEN

Este artículo analiza la relevancia de la gestión de inventarios en la cadena de suministro de la industria de maquinaria y equipos para el procesamiento de cereales, con enfoque en sus implicaciones para la eficiencia operativa. La investigación, de naturaleza teórica y carácter descriptivo-exploratorio, fue desarrollada mediante una revisión bibliográfica sistemática de libros y revistas especializadas en las áreas de logística, gestión de operaciones y gestión de la cadena de suministro. El estudio está estructurado en torno a tres temas: los métodos y prácticas de gestión de inventarios aplicados al sector, la relación entre el control de inventarios y la eficiencia de los procesos logísticos y productivos, y el papel de la gestión de inventarios en la integración y el desempeño de la cadena de suministro. Los resultados evidencian que la adopción de prácticas más consistentes de gestión de inventarios, como la clasificación ABC, los inventarios cíclicos y la gestión del stock de seguridad, contribuye significativamente a la reducción de costos operativos, a la disminución de interrupciones en el abastecimiento y a la garantía de continuidad de los procesos productivos de la cadena. Se concluye que la gestión de inventarios representa un factor estratégico para la competitividad y un mejor desempeño del sector frente a las incertidumbres del mercado mundial, recomendándose inversiones en tecnologías y en prácticas colaborativas con proveedores y distribuidores.

Palabras clave: Gestión de Inventarios. Cadena de Suministro. Procesamiento de Cereales. Eficiencia Operativa.

1 INTRODUCTION

Inventory management represents one of the main points of balance in supply chain processes, contributing to the full achievement of the objectives of industrial organizations and, consequently, of their customers with efficiency and lower cost, fostering the competitiveness and sustainability of the business. When we talk about the industry in the field of machinery and equipment for cereal processing, we understand more intensely the relevance of the topic that was addressed, given the technical and logistical complexity of this segment, regarding the control and availability of inputs, parts and equipment.

In a broader market scenario, increasingly demanding for cost reduction, shorter delivery times and production efficiency, the supply chain in this sector needs greater integration between the links that compose it, in order to make inventory management increasingly efficient and strategic to minimize supply breaks, and ensure the maintenance of production processes. Companies that adopt more consistent inventory management methods and practices tend to perform better in the face of the uncertainties of the world market, as evidenced in recent surveys and studies.

In this context, the present study aims to analyze the relevance of inventory management in the supply chain of the machinery and equipment industry for cereal processing, considering its implications for operational efficiency. To achieve this objective, it seeks to identify the main methods and practices applied to the sector, evaluate the influence of inventory management on logistics and production processes, and examine its impacts on the integration and performance of the supply chain.

This investigation becomes even more relevant academically and in practice, due to the limited availability of specialized literature regarding the analysis of inventory management in this specific industrial segment and the growing demand for solutions that reconcile operational efficiency with the complexity of the market for machinery and equipment for cereal processing. Therefore, this research is based on a systematic literature review, based on authors and recognized studies in the areas of logistics, supply chain management and operations management.

The article was structured in four main sections, in order to ensure logical organization and coherence in the presentation of the study: the introduction, which contextualizes the theme and delimits the objectives of the research; the methodology, in which the procedures and methods adopted to conduct the investigation are described; the theoretical foundation, which gathers and discusses the main conceptual references that support the analysis; and, finally,

the final considerations, aimed at the synthesis of the results, the conclusions of the study and the possible implications for future research.

2 METHODOLOGY

The methodology used in the present work was bibliographic research, based on the study of published texts on inventory management in the supply chain in various segments. This was the research method that was most suitable and allowed a better deepening of the studies. A qualitative approach with an exploratory and descriptive character was adopted with a focus on the contributions of the numerous authors, aiming at a more detailed understanding of what was proposed (Severino, 2017).

According to Santana and Narciso (2025, p. 05), "The qualitative methods, [...], stand out for their depth in data analysis, allowing the exploration of meanings, perceptions, and experiences of the subjects involved in the phenomenon studied".

The procedure adopted consisted of reading selected articles by several authors on the proposed theme, either through digital resources or through the reading of printed material, highlighting important concepts and collaborations that allowed to verify, compare and organize the information collected throughout the process.

To this end, several cultural and scientific contributions related to the subject in question were analyzed. In this way, we sought to remove and analyze several studied citations from several works by different authors, of which the following stand out: Santos *et al.*, 2022, Magalhães *et al.*, 2022, Silva, Moura and Ribas, 2023, Gonçalves *et al.*, 2024, Assereui *et al.* 2025.

Thus, the positions taken during the future article were aided by the positions of the authors consulted and which served as a reference for the formation of the corpus of the present text. (Huhne, 1999)

The entire research was based on ethics and respect for the authors and the works selected and cited in this work. The bibliographic methodology chosen presented the expected results, bringing new possibilities and collaborations in the study of the relevance of inventory management and, thus, proved to be the best choice.

3 THEORETICAL FOUNDATION

This rationale was organized into 3 subtopics. In the first, the Methods and Practices of Inventory Management in the Industry of Machinery and Equipment for Cereal Processing were discussed. In the second, it was researched on Inventory Management and Operational

Efficiency in Production and Logistics Processes. And, finally, in the third, Supply Chain Integration and the Role of Inventory Management were addressed.

3.1 METHODS AND PRACTICES OF INVENTORY MANAGEMENT IN THE INDUSTRY OF MACHINERY AND EQUIPMENT FOR CEREAL PROCESSING

In the market for machinery and equipment for cereal processing, the demand comes from industrial plant projects for wheat, corn, rice mills, feed mills, among others, whether in their complete structure, inclusion of product lines, only electrical or automation projects, supply of spare parts and technical assistance (Vidal *et al.*, 2023).

Projects can be developed from scratch, that is, there is no knowledge of the type of raw material, nor of the components to be used in their structures, or they can be composed of numerous equipment or machines that are already part of a standard product mix, but need customization to suit the specific needs of each customer (Vidal *et al.*, 2023).

Due to the complexity of the processes of development, manufacture, and assembly of these machines and equipment, it is necessary to use various inventory management methods and practices to meet the deadlines of the projects in the company's order book, aiming at customer satisfaction and business profitability (Vidal *et al.*, 2023).

Among the inventory management methods most frequently used in the machinery and equipment industry for cereal processing, we can highlight the ABC Curve, the Cyclical or Rotating Inventory, Minimum Stock or Safety Stock (ES), Order Point (PP) or Resupply Point (RP), because they are methods that allow a better monitoring of stock levels, thus ensuring more efficient management (Vidal *et al.*, 2023).

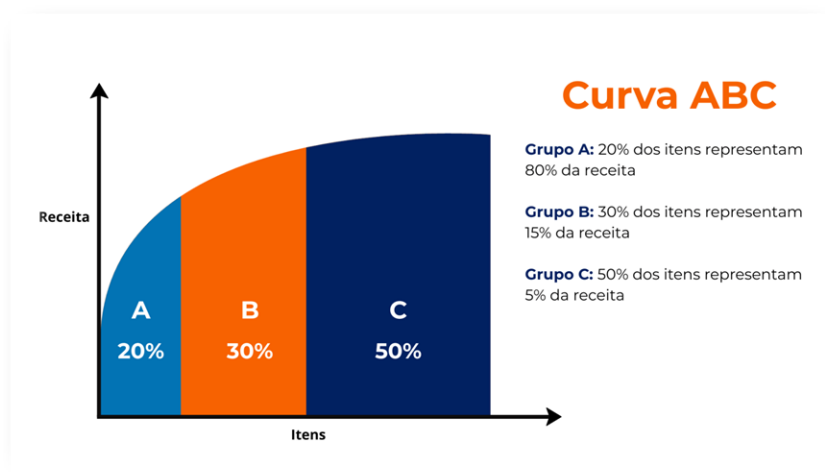
3.1.1 ABC Curve

ABC curve is an analytical tool used for supply chain management, which allows the manager to assess the importance of inventory items based on their sales value, acquisition cost, and availability. "This tool can help detect which items should be prioritized in logistics, improving the accuracy and efficiency of supply chain processes (Jacobs; Chase, 2012 *apud* Silva; Moura; Ribas, 2023, p. 25 - 26)".

The ABC Curve classifies the items according to their importance, allowing a focus on the most relevant products, which is fundamental for the production process of the machinery and equipment industry for cereal processing, as the range of materials from the structures of the machines at their various levels is very complex.

It is understood through Figure 1 that the items located in (A) have special and priority treatment, because they are items of greater criticality and bring the highest percentage of revenue to the company, (B) it then becomes intermediary and (C) the one with the lowest criticality and revenue. (I asserted *et al.* 2025)

Figure 1
ABC curve



Source: <https://logsmartbrasil.com.br/wp-content/uploads/2023/09/Imagem-Curva-ABC-1536x864.png>

In this context of the complexity of the materials of this industry model, it can be seen that the ABC curve is a method of inventory management allied to the good performance of the production processes.

3.1.2 Cyclical or Rotating Inventory

Aguiar and Terazzi (2024, p. 4) state that "Cyclical Inventory is a systematic approach to inventory management, which is distinguished by performing counts and reviews of inventory levels at regular and fixed intervals".

This practice brings security and reliability to inventories, allowing the identification of divergences and facilitating control, especially of products with the highest turnover and value within the processes (Diniz; Parmegiani; Marcucci, 2024).

Carrying out a cyclical or rotating inventory in the machinery and equipment industry for cereal processing that uses a large amount of raw material in its initial processes, such as steel sheets, acrylic sheets or plastic derivatives, such as steel tubes and bars, which are materials that generate industrial waste, scrap, is necessary to avoid delays in the other stages of production (Belisario; Rodolpho, 2022).

3.1.3 Minimum Stock/Safety Stock (ES)

In the view of Fenili (2016 *apud* Assereui *et al.* 2025, p. 5), "safety stock is an additional stock to maintain continuous supply in emergencies". This additional inventory, although it generates a storage cost, allows the industry to ensure that the production process will be maintained, even if there are interferences in the market, whether due to production failures by suppliers, delays by carriers, wars or natural disasters.

The machinery and equipment industry for cereal processing that has a standard product line, such as for the wheat mill segment, are cylinder banks, rotary valves, extractors, sieves and others, most of them choose to have a safety stock in terms of the number of machines, thus bringing greater peace of mind in the face of various situations of shortage.

3.1.4 Purchase Order Point (PP)/Resupply Point (RP)

Still on the perspective of not breaking stocks in order to avoid production stoppage and, consequently, non-compliance with the agreement with customers, the machinery and equipment industry for cereal processing uses the Order Point (PP)/Resupply Point (RP) method as another management strategy.

Assereui *et al.* (2025, p. 05) remind us that "[...] Understanding the right time to order is of paramount importance to avoid bottlenecks that compromise stock security levels [...]". In view of an effective safety stock for efficient production, this monitoring is paramount.

The cereal processing machinery and equipment industry also adopts some other important methods and practices to achieve its objectives, such as Lead time/Resupply Time (TR) and Economic Purchase Lot (LEC).

3.2 INVENTORY MANAGEMENT AND OPERATIONAL EFFICIENCY IN PRODUCTION AND LOGISTICS PROCESSES

The cereal processing machinery and equipment industry is the sector responsible for the manufacture of equipment used in the processing of grains such as wheat, corn, rice, among others.

It is a highly technical segment, as these machines and equipment mostly come from large projects or plants, which requires precision, quality and reliability, both in terms of the product and the delivery time, making inventory management even more critical.

According to Viana (2009, p. 117 *apud* Santos *et al.*, 2022, p. 04), inventory management is "a set of activities that aims, through the respective inventory policies, to fully meet the company's needs, with maximum efficiency and at the lowest cost".

Based on this first, efficiency and lower, the machinery and equipment industry for cereal processing remains focused on increasingly accurate inventory management.

According to Silva and Lima (2020, p. 14 *apud* Magalhães *et al.*, 2022, p. 03):

Inventories have several functionalities for the company in which they are inserted, and their management involves monitoring the movements of incoming and outgoing goods throughout the production cycle, in order to prevent any phase or event of production from being interrupted, which can generate losses to the company.

These precautions in relation to inventory management are justified by the complexity of the processes [several stages of production in this segment of industry] that involve a large number of agents, in their various departments.

Figure 02 below presents us with the various processes, methods [some already mentioned in this article] and results acquired as a result of the good practice of inventory management.

Figure 2

Inventory management methods and processes and their results



Source: <https://procurementgarage.com/wp-content/uploads/2022/07/Gestao-de-Estoques-Conteudo.png>. 2026

It is known that inventory management brings many challenges in a universe of possibilities that are constantly presented in industrial processes, but with good practice the objectives are achieved.

3.2.1 Cost reduction and resource optimization

When it comes to cost reduction in the machinery and equipment industry for cereal processing, it is one of the biggest challenges and objectives of any manager, as it involves all levels of operation and management, which require time, practice and daily monitoring of each immediate manager with each operator, in each of the production processes.

It is also necessary not to lose focus on the processes of acquisition of goods with the purchasing sector to guarantee or improve lead time and in the process of shipping the machinery and equipment produced, seeking to better consolidate the loads and thus better freight values.

Bowersox and Closs (2011 *apud* Gonçalves *et al.*, 2024, p. 03) "state that efficient logistics can provide competitive advantage, contributing to greater flexibility, improved services and cost reduction".

Cost reduction allows the company to ensure profitability and can increasingly invest in technologies to become more competitive in an increasingly demanding market.

3.2.2 Technologies Applied to Inventory Management for Resource Optimization

With technological advancement, an improvement in methods and practices has been achieved and with it, a visible improvement in inventory management, through ERP systems, warehouse automation, use of barcodes and RFID and artificial intelligence for demand forecasting, among others.

For Silva and Moura and Ribas, (2023, p. 32)

The adoption of advanced technology can optimize production and logistics processes, reduce costs, and improve the efficiency and quality of products, tools such as integrated management systems, robotic process automation (RPA), and reverse logistics can bring significant benefits to the entire production chain.

By optimizing resources in all processes of the machinery and equipment industry for cereal processing, with the use of technologies, many of the expectations of inventory management in the supply chain can be fulfilled.

3.3 SUPPLY CHAIN INTEGRATION AND THE ROLE OF INVENTORY MANAGEMENT

As already discussed in this article, the role of inventory management in the supply chain is increasingly relevant to meet the needs of the company and customers, because from good inventory management the company consolidates itself in the market, achieving its mission and expanding its vision for a short and increasingly promising future.

However, when good inventory management is not done, numerous losses can be obtained for the company and, consequently, for the customer [in the wheat segment, when there is a delay in the delivery of the plant, the loss is daily, as it is tons per hour, depending on the plant's flow] who has schedules to execute.

3.3.1 Impacts of Poor Inventory Management

Improper inventory management can generate several problems, from lack of products, excess materials, increased costs, loss of customers, and reduced competitiveness. Therefore, it is essential to have excellent coordination between suppliers, to obtain an efficient production and distribution of machinery and equipment.

Leão (2004 *apud* Gonçalves *et al.*, 2024, p. 07) state that:

[...] In the procurement and purchasing stage, organizations seek and hire suppliers to obtain raw materials or products, and it is essential to establish good relationships with them to ensure quality, competitive prices, and delivery times. A good relationship with business partners, with good follow-up generate satisfactory results for the company.

According to Gonçalves *et al.* (2024, p. 03), "[...] Logistics in the business context is a key strategic function that aims to optimize the flow of products, information, and services along the supply chain.

The company's performance in the market stems from the good practices of inventory management and the entire supply chain, integrated in all its processes, to achieve the results expected by the management, board of directors and partners of the organization.

4 FINAL CONSIDERATIONS

Inventory management is essential for the good performance of the supply chain of the machinery and equipment industry for cereal processing, due to the achievement of the organization's objectives. Its good practice, with a focus on cost reduction and production efficiency, enables it to stand out in the world market.

The research fully met the objectives, when it presented the relevance of inventory management for this specific segment, through the use of assertive methods and practices, highlighting the influence of this management in reducing costs and optimizing resources, as well as the impacts on the logistics performance of the supply chain.

The study showed that it is necessary to maintain and improve these inventory management methods and practices, as it represents a strategic factor for competitiveness and a better performance of the segment in the face of the uncertainties of the world market. Finally,

it is recommended that investments be implemented in advanced technologies to improve production processes, monitoring and control of inventories, in collaborative practices with suppliers and distributors, in improving communication between the productive sectors.

Future research on this topic is essential for a better understanding of the importance of inventory management in this segment of the industry, strengthening the supply chain and growing the interest of new researchers on the subject.

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ARTIFICIAL INTELLIGENCE AND THE CHALLENGES FOR TEACHERS: PROMOTING THE THREE “C’S” OF 21ST CENTURY LEARNING

A INTELIGÊNCIA ARTIFICIAL E OS DESAFIOS DO DOCENTE: PROMOVER OS TRÊS “C” DA APRENDIZAGEM DO SÉCULO XXI

LA INTELIGENCIA ARTIFICIAL Y LOS RETOS DEL DOCENTE: PROMOVER LAS TRES “C” DEL APRENDIZAJE DEL SIGLO XXI



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ABSTRACT

The 21st-century teacher faces major challenges in the educational field, one of the most significant being the proper use of artificial intelligence. Teachers must empower themselves with this technology so that it can assist them with operational tasks such as planning, designing resources, reviewing activities, among others, allowing them to dedicate more time to what is most important in students' education: empowering them with the three “C’s” — curiosity, creativity, and critical thinking — which AI cannot develop, but teachers can. The objective of this publication is to reflect upon and support the idea that the teacher's role should focus on the human dimension of the student, preparing them for a near future in which they must demonstrate these competencies, rather than merely serving as repositories of information, since teachers cannot compete with AI in terms of stored information capacity. Therefore, educators should focus their role on this mission and stop evaluating and teaching through “bulimic” and “vomitive” examinations. In this way, students will be prepared to face a society in which teamwork, empathetic communication, creative proposals, analysis, and criterion-based problem-solving are essential. This is where teachers should invest their time when AI frees them from operational and routine tasks, empowering themselves and relying on this technology as support.

Keywords: Artificial Intelligence. Teacher. Challenges. Learning. Education.

RESUMO

O docente do século XXI enfrenta grandes desafios no campo educacional, sendo um dos mais significativos, e que requer atenção, o uso adequado da inteligência artificial. Os professores devem se apropriar dessa tecnologia para que ela os auxilie em tarefas operacionais, como planejamento, elaboração de recursos, revisão de atividades, entre outras, permitindo-lhes dedicar mais tempo ao que é mais importante na formação dos estudantes: capacitá-los com os três “C” — curiosidade, criatividade e pensamento crítico — algo que a IA não pode fazer, mas o docente sim. O objetivo desta publicação é refletir e sustentar a ideia de que o papel do professor deve estar centrado na dimensão humana do estudante, preparando-o para um futuro próximo no qual precisará demonstrar essas

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competências, e não apenas atuar como um repositório de informações, já que não pode competir com a IA em capacidade de armazenamento de dados. Por isso, os docentes devem concentrar sua função nessa missão e deixar de avaliar e ensinar da forma como fazem atualmente, com exames “bulímicos” e “vomitivos”. Dessa maneira, os estudantes estarão preparados para enfrentar uma sociedade em que o trabalho em equipe, a comunicação empática, a elaboração de propostas criativas, a análise e a solução de problemas com pensamento crítico serão fundamentais. É nisso que os professores devem investir seu tempo quando a IA os libera de tarefas operacionais e rotineiras, apropriando-se dela e utilizando-a como apoio.

Palavras-chave: Inteligência Artificial. Docente. Desafios. Aprendizagem. Educação.

RESUMEN

El docente del siglo XXI se enfrenta a grandes retos en el ámbito educativo, uno de los más significativos y que requiere atención es el uso adecuado de la inteligencia artificial, empoderándose de esta para que lo ayude en tareas operativas como la planificación, el diseño de recursos, revisiones de actividades, entre otras, y que le quede tiempo libre para dedicarlo a lo más importante en la formación de los estudiantes, que es empoderarlos con las tres “C”: curiosidad, creatividad y pensamiento crítico, que la IA no lo puede hacer, pero el docente sí. El objetivo de esta publicación es reflexionar y sustentar de esta manera que el rol del docente se debe centrar en la parte humana del estudiante, prepararlo para el futuro cercano en el que tiene que demostrar estas competencias y no solo ser un repositorio de información, ya que no puede competir con la IA en capacidad de información almacenada, por eso los docentes deben enfocar su función en eso, y dejar de evaluar y enseñar como lo hacen, con exámenes bulímicos y vomitivos. Así, que los estudiantes se van a enfrentar a una sociedad donde se trabaje en equipo, se comunique de manera empática, realice propuestas creativas, analice y dé soluciones con nivel criterial, eso es en lo que los docentes deben invertir su tiempo cuando la IA los libera de tareas operativas y rutinarias, empoderándose y apoyándose en ella.

Palabras clave: Inteligencia Artificial. Docente. Retos. Aprendizaje. Educación.

1 INTRODUCTION

All of us who are immersed in the academic world know that teaching in times of AI is a great challenge, because education is supported and empowered by technology, but it is the responsibility of the teacher to apply it effectively, innovatively, ethically and with educational disruption. Education in all its areas and educational levels implements the use of Artificial Intelligence, but it is not only necessary to know tools, but also to have the ability to apply the strategies and methodologies that allow it to be used well.

While it is true that artificial intelligence has existed for a long time, practically since the appearance of web 2.0, *e-learning* and other technological developments, it has been advancing each time, as has the knowledge society, generating multiple challenges, especially for teachers, both university and other educational levels. Therefore, we must look carefully at all those elements and factors that can help us to be better teachers and managers of education. The objective of this publication is not only to reflect but also to sustain that the role of the teacher should focus on the human part of the student, preparing him for the future where he must demonstrate these competencies and empathetic leadership.

2 ARTIFICIAL INTELLIGENCE AND TEACHER CHALLENGES

The topic I will address is artificial intelligence and the challenges of the teacher. To begin with, I start from a very important idea: *times change... universities too*. That's right, dear colleagues, readers, universities must move hand in hand with technology; We cannot stand on the sidelines. Think, for example, of how cinema has changed: we used to have to go to a cinema in person, and now we have streaming platforms such as Netflix. In transportation, we have applications such as Didi, Uber or Cabify. When it comes to shopping, there are platforms such as Temu, AliExpress or Amazon. Technology, science and artificial intelligence have advanced in all areas of work, business, personal, and of course, also in education, where you and I are involved.

Education must go hand in hand with these advances and take advantage of them to empower not only teachers, but also to benefit the essence of our work: students. Therefore, if times change, universities must do the same. They cannot be left behind; must accompany this process of transformation, otherwise they would represent a setback for educational environments.

Artificial intelligence, as I mentioned, has brought us great challenges in different areas: in companies, commerce, technology, the home and, of course, in education. It has an essential characteristic: it seeks to carry out activities that, operationally, human beings perform in their

work or in any environment. From this, we can identify thousands of AI-based tools, and more applications are constantly being created. I will mention six of them, only six, because the complete list would be endless. These will help us to reflect on how we can empower ourselves as teachers, especially in operational tasks.

Figure 1

AI frees up operational activities

La IA libera a los docentes de actividades operativas



La IA puede **liberar a los docentes** de las tareas más tediosas y les permite hacer lo que realmente deben hacer, enfatizar en el aspecto **moral**, lo **valores**, el trabajo en **equipo**, la **empatía**, la **creatividad**.

Source: Authors.

The first is Squirrel Ai Learning. This tool, originated in Shanghai, China, more than fifteen years ago, has recently entered the American market for a very interesting reason: it offers students at all levels, from elementary school to university, a virtual teacher available outside of class hours. This online teacher, an avatar with artificial intelligence, helps to review the topics developed according to the level and learning style of each student. In this way, it reinforces the contents worked on by the teacher, acting as an assistant or assistant teacher. It is like having, many of us know from experience, a head of practice or assistant at the university who supports the teacher. This virtual assistant, on the other hand, helps the student to improve their skills according to their level and needs.

The second tool is DreamBox, very similar to Squirrel Ai Learning, but with a focus on learning styles and levels. There are students who learn best by listening, others by visualizing, and others through more kinesthetic activities. DreamBox, through artificial intelligence, offers personalized accompaniment, allowing the student to advance and review at their own pace. In addition, it gives the teacher the possibility of visualizing the progress of their students: what level they are at, how they have improved and what aspects require reinforcement. In this way, the teacher can better prepare their next sessions, providing feedback and consolidating learning.

The third tool I want to mention is Gradescope, a great ally in task review. This platform allows students to automatically provide feedback, even based on previously defined rubrics. Thus, those operational tasks that would take us hours or even days when we have 60, 100 or 150 students can be solved in much less time.

These three tools are examples of applications that help in operational tasks, freeing up time for the teacher to focus on deeper aspects of the educational process. In addition to these, there are four others, which I am sure we all know: Turnitin, ChatGPT, Duolingo and Gemini.

Turnitin, widely used, works with artificial intelligence to support the detection of plagiarism and the correct use of citations and references in research papers, theses or essays. ChatGPT, a classic of recent years, has become a tool that offers fast and fluid information, facilitating search, writing and analysis processes. Gemini, which has become our smart assistant in the palm of your hand. Finally, Duolingo, which combines artificial intelligence with gamification, allows you to learn different languages in a playful and personalized way. With motivational messages such as "Okay, you can do it!" or "Congratulations!", the system awards rewards, stars and progress levels, adjusting the challenges according to the user's individual progress.

These seven tools, three more specialized and four widely known, represent just a sample of the possibilities offered by artificial intelligence in the educational field. However, they reveal a great pending challenge: teacher training. There are hundreds, even thousands of tools that neither you nor I know yet, because new ones are constantly being created for different areas: history, mathematics, English, among many others. We are getting to know some of them according to our field, but there is still much to discover. But what does the professor, the university professor, the teacher at all levels, need to be able to empower themselves with these tools? You need to be trained.

A survey conducted in 2025 asked the question: *Is artificial intelligence important in education?* And the results were very revealing. Four Latin American countries—Peru, Mexico, Chile, and Argentina—as well as Spain, identified teacher training as a prevailing need. Of course it is, and not only in the sense of knowing tools, because that today can be learned with a click on YouTube or Google, but in how to really empower ourselves with them, how to select the most appropriate ones according to our area or subject. If I am an engineer, psychologist, lawyer, history or literature teacher, I must identify the tools that respond to my needs, applying approaches and methodologies that help me form better human beings. That is the part that artificial intelligence does not provide, and that is precisely why teacher training is so necessary in our Latin American countries. And it's good that it's recognized like this, because it's urgent.

In addition, this training should not depend solely on a director, rector or ministry enrolling us in courses or workshops. We must also self-manage our own training. We have a huge amount of resources available: databases, YouTube channels, free webinars, conferences, online congresses and much more. Therefore, it is essential to empower ourselves and take responsibility for our own training, in addition to that offered by the educational institutions where we work.

Figure 2

Challenges of the teacher in times of AI

Retos del docente en la era de la AI !!



Source: Authors.

3 THE THREE C'S OF HUMAN LEARNING

But training should not be limited to knowledge of operational tools. It must also focus on what I call the three "Cs" of humanization. Artificial intelligence can be very efficient and handle enormous amounts of information, we have it on our smartphones, just a click away, but it lacks creativity, awareness and human compassion. Artificial intelligence cannot offer that, but teachers do. We have emotions, empathy, the ability to accompany students in their process, whether in face-to-face, virtual or blended environments. That is the shortcoming that artificial intelligence does not cover and that we must assume as educators. Therefore, there is a great challenge here: the teacher must be creative, have awareness and critical analysis, and demonstrate human compassion in different situations.

Teachers are leaders in society, and we must manage this entire technological process, empowering ourselves with artificial intelligence not to replace what we do, but to free ourselves from operational tasks. As I mentioned before, technology tools can help us reduce the time spent on practical tasks that are often long or tedious, such as reviewing or giving feedback on work, making materials, or taking notes. By using artificial intelligence for these tasks, we can dedicate more time to the essence of our work: reinforcing ethics, morals, values, teamwork

and coexistence. We live in society, and our students will go out to live and work in society, in universities, companies and institutions. That is why we must promote empathy, warmth and creativity from a young age, so that when they reach university they already bring that innovative spirit. And if they don't, it's up to us to encourage it in them.

Empowering ourselves with artificial intelligence allows us to free ourselves from operational tasks and focus on what technology cannot replace: ethics, values, empathy, creativity and teamwork. This can save us up to 50% of the time we spend on the most routine tasks of the day-to-day, allowing us to focus on the human part of the educational process.

That human part is expressed in dialogue, in teamwork, in closeness with students: that "how are you guys, how are you doing, how can I help you?" We cannot limit ourselves only to the literal or technical aspects of the activities. We work with human beings, not with machines or robots. They feel emotions, joy, sadness; and we must be there, accompanying them.

However, in the world there are still schools and universities where some teachers, fortunately less and less, continue to work with their students as if they were robots, limiting themselves to filling them with repetitive information and applying exams over and over again, just to mark answers, literally. This makes the student an operative, monotonous being, and does not prepare him for the challenges of the future. Those teachers who continue with repetitive methods, constant exams and mechanical activities, are unwittingly training *human robots*, not real students. They want the student to accumulate information, but the question is: will a student be able to know more than Google, ChatGPT or other databases? Of course not. The student is a human being, not a memory machine. It can never exceed the amount of information that exists on the internet or in digital databases. Therefore, insisting on methodologies based on memorization only leads to competing with artificial intelligence, something impossible.

We should not train students who imitate artificial intelligence, but guide them to be better human beings, professionals who can work in a team, who are leaders, empathetic, creative, who can investigate, because in order to reach that creativity they have to start with curiosity from an early age. They must be guided towards what artificial intelligence cannot do. We need to empower them with the three "Cs": **curiosity, creativity, and critical thinking**.

Figure 3*Teachers must promote creativity***Promover la creatividad!!**

Source: Authors.

A student with critical thinking can be a leader, a great businessman, a principal, a teacher, an engineer, or a lawyer. Critical thinking gives you discernment, analysis, and creative ability. We need people who innovate, not repeat what they see every day. Innovation, we always say, is the key to success. However, many colleges and universities still apply repetitive exams. How do we expect students to be creative or innovative if we continue to teach mechanically?

Curiosity is the basis. I always say it, when I train primary school teachers, that if we promote curiosity in students from a young age, we will have much more competent students at university. A curious child asks, analyzes, compares, and creates. When that student reaches the higher level, he dazzles with his creativity and innovation. But if during his childhood he has received a rigid education, where he is told "don't paint like that", "don't draw like that", "don't feel like that", "don't look like that", when he gets to university he will ask "and how do I do it?", because all his life he was told how to do it. In other words, it did not develop creativity or innovation.

I know that each of you will say: "Yes, we receive students like that at the university." Unfortunately, we still receive them. So, our task, our challenge in universities, is very complex. Let's imagine the professionals who are being trained in the future: the groups of innovative, creative and empathetic teachers, and those who do not, those who continue with rigid activities, pretending that the student memorizes, learns, takes exams and repeats everything by heart. What will happen fifteen or twenty years from now? What will the challenge be like for them? They will not be able to face or function in a society that is going to devour them; they will not

be able to really develop. They will only be carriers of information, and we already know that the information is here in the click, in the palm of the hand, in all the applications we have.

We need students who are critical, strategic, creative, compassionate, humane, empathetic, who identify with how their partner feels, not who live their world mechanically. That's why we ask: "How are you guys? How are you? How have they done?" Before starting a face-to-face, virtual or blended class session, we should not start by saying: "Today we will address the history of...", but "How are you? How was your weekend? Is everything okay?" First, the human part. I know that will take us ten, fifteen or twenty minutes, but it is essential, because that is what artificial intelligence cannot do and we can. It is our task. If we humanize by example, empathize with example and motivate by example, we will train professionals who, although they will be experts in their field, will also, in essence, be empathetic human beings.

Education has a very long and challenging road ahead. The process that we have to go through is really complex, because there is a great debate in the world about technology, science and artificial intelligence: whether to use the *smartphone* or not, whether to take the cell phone to class, whether to allow the internet or not. While these issues are being discussed, science and the knowledge society continue to advance. We must go hand in hand, always remembering that technology, artificial intelligence and whatever comes tomorrow, which we do not know what it will be, are already among us.

Figure 4

Education has a long way to go

A la educación le queda un largo camino por recorrer



La educación es uno de los sectores que **más tarda en adaptarse a la tecnología, si eso no cambia**, en unos 20 o 30 años nos espera un **futuro muy complejo**.

Source: Authors.

Today we have humanoid robots like Ameca, or like Sofía, who was in Virtual Educa. In Virtual Educa Sofia gave a lecture in a room that left the participants who listened to her shocked. We are surrounded by technology, but Sofía does not have the human warmth that

Dr. Milagros Huamán Castro has: "How are you? How are you?" showing a smile. That's the difference. Sofia has an incredible memory, with everything on Google in her memory, excellent. But we have something that she doesn't have. Education must address this, which is why all teachers must be committed to this change. The essence is not in learning to use artificial intelligence tools, that is simple; just as we learned Zoom or Moodle, it is not complex. The essence is to use them properly, without neglecting the human part, creativity, compassion and ethics. That is really the challenge of the teacher in this era of artificial intelligence.

This challenge requires our predisposition, the desire to relearn every day. To transform ourselves into this new essence, we must learn to unlearn in order to be able to constantly relearn, because tomorrow something different will appear and it will not be the same artificial intelligence. We will have to work with it, but the essential thing is to break our own paradigms.

Many times, in universities or colleges, we follow lifelong routes, and it is difficult for us to break those schemes. Many teachers find it difficult to do so, or want to break them, but they find themselves with institutions that follow outdated models. Or, the principal or rector wants to innovate, but some teachers are resistant, it is difficult for them. You have to train them once, twice, three times, motivate them. The task is arduous, both for those who manage and for teachers, because we all have to break the paradigms that bind us. And those paradigms are not in a book; they are in our way of thinking, in our decisions and in how we take on the new challenges brought by the society of knowledge, research and technology, where changes are constant. This calls us to constantly update ourselves and to stay at the forefront in our areas, subjects or professional careers.

The challenges are many. The first is to promote creativity, a great challenge for teachers in each of their subjects. You are an expert in engineering, economics, pedagogy, medicine, law, art or psychology: how do you promote creativity in your career, in postgraduate or in the doctorate? If you teach at school, how do you encourage it?

To propose activities that promote creativity, we must plan in advance. It is an essential step. If I am going to use artificial intelligence, I must have selected my tools, but also plan how I will promote creativity with students so that in the end each one contributes something different, something that artificial intelligence cannot contribute.

Motivation must also be permanent in our classrooms. Even when giving feedback, when we see that a job is wrong, we shouldn't say, "Peter, this job is a mess," no. We can say: "Pedro, I have seen that your work has not reached the expected competencies. Maybe you've been tired or distracted. I recommend you review this book, this article, and reflect to rethink it." Even in the most critical moments we must motivate.

Figure 5

Teachers must promote constant motivation

La motivación



Source: Authors.

When students get the highest grade, we congratulate them, we give them a badge, a happy face. I, in graduate school, give badges to my doctoral students. But if the task is not right, we should not react negatively, emotionally abusing them. On the contrary, we must reflect with them: "I know that next time you will do well, I trust you, you can do it". This is how we motivate them to continue striving, because if not, they become demotivated and give up. Many students say, "I can't take it anymore," and it's not that they can't, but that they lack motivation. Sometimes they do not receive it at home, and it is we, the teachers, who must provide it, in postgraduate studies, in their careers or at school.

Another big challenge is empathy. Artificial intelligence cannot be empathetic or motivating or creative, but we can. We must ask them, "Are you wrong? Haven't you slept because you worked all night? Don't worry, rest." Ask them how they are, how they feel, what they need. And not only be empathetic with them, but promote empathy among students, so that they do not live individually, but learn to be empathetic with their classmates. That part is fundamental and we must promote it by example.

We must also promote collaboration. Many times students say: "No, Dr. Milagros, I work alone, I don't like to work in a team." We cannot say "it's okay", but guide them to understand the benefits of collaborative work, whether virtual or face-to-face. Teamwork strengthens the final product, because each one contributes from their area, it is finished faster and the result is better. In addition, the student learns that he will not live in isolation: he will live in society, and

when he graduates as an engineer, accountant, doctor, pedagogue, communicator, economist, psychologist or mathematician, he will have to work in a team. That is why, from university or college, we must promote collaboration, mutual help and constant guidance, because they will live in society and must learn to overcome each challenge together.

The other great challenge is critical thinking. How much it costs us for the student to work on critical analysis. They almost always reach the literal level. In reading comprehension we have three levels: literal, inferential and criterial. Most students stay at the literal level, especially when it is only evaluated with memory tests, with alternatives A, B, C, or D. Those who continue to take repetitive exams make the student remain at that literal level, without advancing to the inferential level and even less to the critical. Critical thinking will help the student, when they graduate, to be a leader in the company, in their work or in any space where they work. It will give you the ability to discern, analyze, give your opinion, and make appropriate decisions in your professional life.

Promoting critical analysis in the classroom is an essential issue, and artificial intelligence cannot do it. We must have this reflection every day, together with our students, from the different subjects in which we accompany them.

Figure 6

AI will change the world

La IA es como la nueva electricidad, *cambiará el mundo.*
Depende del humano que le dé la utilidad para ayudar y mejorar la vida.



Source: Authors.

4 CONCLUSIONS

Artificial intelligence is, in its time, what electricity was. Before electricity, the world had another way of living: lighters, candles, candlesticks were used, people went to bed early. Then the world changed. Electricity not only brought light, but also appliances and everything that works today thanks to it.

Artificial intelligence has arrived in the same way: it has arrived in the world, in commerce, in cinema, in technology, in the environment, in education. But it is up to human beings to use it to improve the quality of life. In our environment, it depends on how the teacher is empowered by this tool, but as an operational support, not as a substitute. To know it in order to take advantage of it in routine tasks and, over time it frees us, to strengthen creativity, critical thinking and human awareness. The essence of the human being is what we will not find in artificial intelligence or in any of its tools.

As education professionals, we have that empathetic and motivating commitment to our students, and the permanent commitment to self-train to be able to give the best of ourselves, because they are our reason for being.

We must continue to research and reflect with a critical, disruptive and innovative look, because artificial intelligence, education and our role as teachers at this time is challenging and requires a commitment to human quality.

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A THEORETICAL PHILOSOPHICAL ESSAY ON THE CONNECTED HUMAN
ENSAIO FILOSÓFICO TEÓRICO SOBRE O HUMANO CONECTADO
UN ENSAYO TEÓRICO Y FILOSÓFICO SOBRE EL SER HUMANO
CONECTADO



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ABSTRACT

The setting for this philosophical-theoretical essay is the current concern about technological advancements and rapid innovations in the field of computing, present in the daily lives of almost everyone around the world. Today, it is impossible to imagine a routine, whether personal or professional, without the phenomenon of connectivity. Imagine a world without the internet! Impossible. The intention here is to engage with some available theories on the subject and provoke reflections on connected humanity. To this end, the structure of this essay presents three sub-themes. The first is the "Virtual Narcissus," that individual who is connected to the screens of their remote connection devices to interact with their groups, hold work meetings, study, have fun, date, snoop, among other connections. After all, the internet is the new communication paradigm in which we are immersed. The second is the "Post-human," the result of a new non-Darwinian evolution, carried out in laboratories and not in nature, with the contribution of Genetic Engineering, Biomedical Engineering (which includes contributions from Mechanics, Electrical Engineering, Information Technology, and, undoubtedly, Biology). And the third, "Philosophical Counseling: from Ancient Greece to the present day," is another tool available to address people whose existential issues do not require psychotherapeutic treatment. Philosophical Counseling is closer to Philosophical Guidance, whose guiding thread is the premises of philosophers and not the manuals of psychological and behavioral diagnoses or disease codes. The main focus of Philosophical Counseling is not on illness or mental disorders, but on the experience and existence of the individual seeking self-examination. Through careful research conducted with thinkers who have offered their reflections and philosophies on the theme of the globalized and connected world, the aim is to establish dialogues that can briefly guide the condition of the current being-there, being-in-the-world, Dasein.

Keywords: Philosophical Anthropology. Therapeutic Philosophy. Post-Human.

RESUMO

O cenário deste ensaio filosófico-teórico são as inquietações atuais sobre os avanços tecnológicos e as rápidas inovações no campo da informática, presentes na vida cotidiana de quase todos ao redor do mundo. Hoje não é possível imaginar uma rotina, seja pessoal ou profissional, sem o fenômeno da conectividade. Imagine um mundo sem internet!

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Impossível. Pretende-se aqui dialogar com algumas teorias disponíveis sobre o tema e provocar reflexões sobre a humanidade conectada. Com esse objetivo, a arquitetura deste ensaio apresenta três subtemas. O primeiro é o “Narciso Virtual”, aquele sujeito que está conectado com as telas de seus aparelhos de conexão remota para se relacionar com seus grupos, fazer reuniões de trabalho, estudar, se divertir, namorar, bisbilhotar, entre outras conexões. Afinal, a internet é o novo paradigma de comunicação no qual estamos imersos. O segundo é o “Pós-humano”, aquele que é resultado de uma nova evolução não darwiniana, realizada em laboratórios e não na natureza com a contribuição da Engenharia Genética, a Engenharia Biomédica que conta com a contribuição da Mecânica, da Elétrica, da Tecnologia da Informação e, sem dúvida, da Biologia. E o terceiro, o “Aconselhamento Filosófico: da Grécia Antiga até os nossos dias”, que é mais uma ferramenta disponível para tratar de pessoas cujas questões existenciais não necessitam de tratamento psicoterapêutico. O Aconselhamento Filosófico se aproxima mais do aspecto de Orientação Filosófica, cujo fio condutor são as premissas dos filósofos e não dos manuais de diagnósticos psicológicos e comportamentais e nem dos códigos de doenças. O foco principal do Aconselhamento Filosófico não está na doença ou nos transtornos mentais, mas na experiência e na existência do indivíduo que busca examinar-se. Através de uma pesquisa cautelosa, realizada com pensadores que dispuseram suas reflexões e suas filosofias sobre o tema do mundo globalizado e conectado, a proposta é estabelecer diálogos que possam nortear, brevemente, a condição do atual ser-aí, o ser-no-mundo, o *dasein*.

Palavras-chave: Antropologia Filosófica. Filosofia Terapêutica. Pós-Humano.

RESUMEN

El contexto de este ensayo filosófico-teórico es la preocupación actual por los avances tecnológicos y las rápidas innovaciones en el campo de la informática, presentes en la vida cotidiana de casi todas las personas en el mundo. Hoy en día, es imposible imaginar una rutina, ya sea personal o profesional, sin el fenómeno de la conectividad. ¡Imaginen un mundo sin internet! Imposible. La intención aquí es abordar algunas teorías disponibles sobre el tema y provocar reflexiones sobre la humanidad conectada. Para ello, la estructura de este ensayo presenta tres subtemas. El primero es el “Narciso Virtual”, ese individuo conectado a las pantallas de sus dispositivos de conexión remota para interactuar con sus grupos, celebrar reuniones de trabajo, estudiar, divertirse, tener citas, fisgonear, entre otras conexiones. Después de todo, internet es el nuevo paradigma de comunicación en el que estamos inmersos. La segunda es la «Posthumana», resultado de una nueva evolución no darwiniana, llevada a cabo en laboratorios y no en la naturaleza, con la contribución de la ingeniería genética, la ingeniería biomédica (que incluye aportaciones de la mecánica, la ingeniería eléctrica, la informática y, sin duda, la biología). Y la tercera, «Orientación filosófica: de la antigua Grecia a la actualidad», es otra herramienta disponible para abordar a personas cuyas cuestiones existenciales no requieren tratamiento psicoterapéutico. La orientación filosófica se asemeja más a la guía filosófica, cuyo hilo conductor son las premisas de los filósofos y no los manuales de diagnósticos psicológicos y conductuales ni los códigos de enfermedades. El enfoque principal de la orientación filosófica no está en la enfermedad o los trastornos mentales, sino en la experiencia y la existencia del individuo que busca la autoexploración. Mediante una investigación minuciosa realizada con pensadores que han ofrecido sus reflexiones y filosofías sobre el tema del mundo globalizado e interconectado, se busca establecer diálogos que puedan orientar brevemente la condición actual del ser-ahí, el ser-en-el-mundo, el *Dasein*.

Palabras clave: Antropología Filosófica. Filosofía Terapéutica. Posthumanismo.

1 VIRTUAL DAFFODIL

The century. XX, in the era of rationality, was marked by two world wars, the explosion of two atomic bombs and a Cold War that put the world under the fear of an atomic cataclysm. From the 1950s, with the appearance of the computer developed by mathematician Alan Turing (1912 – 1954), a new tool came on the scene.

The military world of the Soviet Union and the United States axis needed to ensure secrecy and non-espionage of military strategies during the Cold War. Physicists, mathematicians, engineers and technicians worked hard to develop equipment that would guarantee the secrecy of these strategies, and the computer began to be used for this purpose. Connecting two computers was a challenge to be faced. Until the end of the 1960s, in the USA, the first connection between two computers occurred in two distant locations, initially in a very rudimentary way, but a new communication paradigm emerged there, the internet.

By the end of the 1970s, the United States of America had released this new means of communication for public use by civil society. At first, universities and industries assimilated the new model. It was the beginning of a revolution in communications. As the cost of this new "media" became cheaper, public access increased. Mobile devices were also the clear demonstration of communication transformations .

With each new generation, mobile devices brought quick advantages to users, until the 4th generation of devices appeared, called smartphones, which, like personal computers, gained access to the world wide web. Since then the world has been connected in a great network. The latest generation of mobile devices, 5G, and smartphones promote the so-called IoT, an acronym for "internet of things". This way everything will be connected online.

During the pandemic, in the third decade of the 21st century. In the twenty-first century, the world was placed in social isolation. Personal computers and mobile devices were fundamental tools to support isolation and social distancing. Schools, organizations, institutions, and society at large have benefited from online virtual connections. Technology helped to endure the difficult phase and made the world, in fact, more connected.

Compared to the XVIII century. XX, which after the "wars" developed new technologies that revolutionized the way humans relate to each other in the world, as well as the 21st century. XXI has brought and will bring new technological revolutions that will also change the relationship of humans in new scenarios, as is the case with the introduction of a new tool, Artificial Intelligence (AI) in 2024.

And Philosophy, which systematically seeks the knowledge that comes from the Scientific, Physical and Social fields, will not refuse to contribute, problematizing and discussing these issues to develop a philosophical thought contemporary to the 21st century. XXI.

1.1 THE MYTH OF NARCISSUS: A CONTEXTUALIZATION

The river-god Cephisus kidnapped and possessed the nymph Liriope. When she realized that she was pregnant, Liriope remained with diffuse feelings, but gave birth to Narcissus, a child of rare beauty who enchanted everyone, which made her cautious because she feared the gods of Olympus for being intolerant of mortals who stood out from the rest. With that, the nymph went to consult the soothsayer Tiresias, who predicted that the boy would have a long life, as long as he never saw himself reflected.

As a teenager, Narciso realized that he caught people's attention and that this was due to his unusual beauty. As a young adult, the nymphs, the girls and the boys competed for his love. Faced with all of Narcissus' denials, one of his suitors claimed that he did not live under the laws of mortals. He raised his hands to the heavens and asked the gods of Olympus that Narcissus fall in love with someone, but that it would never be reciprocated. Nemesis, who punishes the excesses of mortals, complied with the boy's heartbroken request.

During a hunt, Narcissus got lost from the group and found himself alone. He was watched among the foliage by the nymph Echo, who had been cursed by Hera and distracted her to cover up for Zeus while he loved mortals. Because of Hera's curse, Echo, who talked a lot, could only speak the last words he heard, without ever being able to answer or talk to anyone.

Observing Narcissus in the forest, Echo was enchanted by his great beauty and thought he was a god. But Echo thought out loud and Narcissus heard his voice coming from inside the forest and wanted to know who was there. Echo introduced herself to Narcissus, who vehemently reprimanded her for having approached him. Saddened, Echo was paralyzed, while Narcissus walked away from her. But, driven by Narcissus' beauty, Echo continued to follow him hidden among the foliage.

Narcissus then came to a clearing where there was a large reflecting pool fed by a narrow watercourse. As he reclined on the lake to drink water, Narcissus saw his image reflected.

The prophecy of Tiresias and the curse of Nemesis began to be fulfilled. Narcissus was intoxicated by the great beauty of the young man without knowing that it was his reflected image. The image in the reflecting pool seduced him, and Narcissus, upon hearing Echo, (also seems

to contradict the curse) deluded himself that he was also reciprocated by the image reflected in the reflecting pool, mistaking the echo as if it were the voice of the image that spoke to him.

For several days, Narcissus remained leaning over the water mirror, talking to his love and listening to his amorous vows, which were nothing more than his own words, distorted by the echo of Echo and confused, he did not eat or hydrate.

Echo was the only witness to how Narcissus languished...

Recognizing the truth and seeing that the image also languished, Narciso concludes: "You are me!". Disappointed, he thinks: "what a strange loneliness of mine... I have and I don't have myself... Which of us two is just a mirage? Goodbye...", he said goodbye to life, lying next to the reflecting pool...

Narcissus' body disappeared. In the place where he was, a flower with a single stem, the daffodil, was born. In Hades, Narcissus continued to see himself reflected in the river Styx, the river of forgetfulness. (Adapted from GUASCO, 2011).

1.2 REFLECTIVE ELEMENTS TAKEN FROM THE MYTH

Teles (1974) states that myth is an explanatory context to clarify a hitherto unknown fact, and Abbagnano (2018) adds that a myth, as it is a narrative, has the function of explaining some common sense phenomenon.

From the myth of Narcissus, one can draw elements for some contextualized philosophical reflections.

Tiresias' prediction about the fate of Narcissus can be related to the current scenario and represent the market and the voracious capitalism to which we all live in it, something like a destiny. A destination created by Marketing, Digital Marketing, whose function is to establish new needs of users who browse digital networks. *Influencers* play an important role in this destination.

By insistently rejecting the affective appeal addressed to him, Narcissus became excluded from interpersonal affective relationships, a condition that imposed loneliness on him. This loneliness that, when lost from its "group of hunters", becomes existential, something close to cancel culture. The "group of hunters" can also represent the groups of belonging, affinity, help, and interaction of peers that are created in connected life.

The nymph Echo, when observing him and thinking that he is a god/consumerist, behaves like the "echo chamber", that is, he acts like the algorithms that capture the navigator's data on the network and offers him what he "needs", placing him inside a "bubble".

Upon seeing the reflecting pool, Narcissus goes there to quench his thirst, but this mirror is fed by a narrow watercourse that may represent the products offered by the organizations that control the digital environment. This reflecting pool can also represent the kidnapping of your imago through the screens of smartphones, tablets, computers, smart TVs. As the reflecting pool captured the image and beliefs of Narcissus, he was as if intoxicated by himself, which usually happens with our media screens.

Echo, fascinated by Narcissus, confuses him with the repetition of his last words, so by comparison, echo becomes something akin to ruminating, obsessive thoughts.

It is only when Narcissus is exhausted of his vital forces and close to death by starvation that he recognizes that the virtual imago with which he had fallen in love was himself. His philosophical question then arises: which of us is just a mirage? In the place where he died, after his body disappeared, a flower with a single stem, the narcissus, appears, which has the same root as the word narcotic.

Disturbed Narcissus has altered consciousness. Etymologically, the word Narcissus has its origin in the Greek, whose root is *narké*, which means numbness or torpor, and from the Greek suffix *issos*, which forms names, such as plants and diseases. By free translation, 'sick with numbness', 'numbed by self-love', 'behavior numbed in himself', subjected to the murmurs of the Echo, here represented by intrusive thoughts.

In Hades, Narcissus continues to observe himself in the Styx, the river of oblivion. When a subject empties himself in the virtual world, like Narcissus in front of the reflecting pool, he is no longer useful to the system, so the system is no longer useful to the system.

The virtual world voraciously desires to find our daffodils, capture them, consume them, and abandon them into oblivion. In this process, the system feeds back, which can be considered as virtual narcissism or the search for virtual narcissus.

A new philosophical thought arises naturally from changes that occur in the social, scientific and cultural fields in the age of connection. Thus, current changes affect the direction of contemporary philosophical thought, says Teles (1974). This author adds that although the mission of Philosophy is different from the mission of Science, both produce Knowledge. Thus, knowledge can occur in a systematic, rationally organized and elucidative, critical and speculative way. If it occurs in an unsystematic, vulgar and popular way, uncritical, imprecise and self-contradictory, it will be "common sense" or a non-rigorous understanding, as Rosa (2021) says.

Through the eyes of the Philosophy of Mind, which is the youngest of the areas of study and knowledge incorporated into the philosophical tradition, whose fundamental issue is the

mind-body problem, founded by the French philosopher Rene Descartes (1596-1650) with *res-cogitans* and *res-extensa*, roughly speaking, the Philosophy of Mind deals with the dynamics of the body-minds present in nature, says Moraca (2013).

For Abbagnano (2018), the Philosophy of Mind is a reflection of the nature and basic properties of the human mind and the analysis of the cognitive capacities of the thinking subject, where mind, soul and spirit are synonymous with intellectuality, whose semantic variation occurs according to the global theoretical framework in which it is inserted.

In this way, Teles (1974) states, it is possible to use Axiology, the critical theory of values, since value corresponds to a need or lack that causes imbalance, that generates tensions that determine the value of an object, obtaining pleasure. Equivalent to a biopsychic homeostasis, I would say.

For Teles (1974) these needs are somatic, social, logical, aesthetic, ethical or religious – these are generally of an absolute nature. However, values are always arranged between two poles, the positive and the negative. It also says that each subject has its own hierarchy of values. These are relevant concepts to understand the phenomenon of virtual narcissus.

When analyzing the concept of "virtual", Abbagnano (2018) offers us the definition that virtual is seen as something potential. The concept of "virtual reality", Abbagnano continues, emerged in the 1980s in the field of Information Technology (IT) to refer to a possible and operative reality, artificially constructed, which produces real effects on the human experience and on the perceptual reality induced by devices.

This artificial reality is called virtual, because it concerns images and not tactile objects, and this "substitution" causes internal sensations with minimal physical contact, usually only the visual and auditory, therefore, a matter of Aesthetics.

Torres (2012) clarifies that the massive use of the internet is a way of coping with social isolation and that it promotes a stimulus to global teleparticipation, but that in some cases it generated altered states of consciousness, a fact observed during the Covid-19 pandemic.

The rampant use of the Internet is already considered a public health problem, Loss declares; War; Souza (2021). They also affirm that unbridled use promotes ruminative self-awareness, the echoes, whose self-attention leads the user to a negative axiological evaluation of himself and thus causes mental disorders.

With the introduction of cancel culture on the internet in 2015, a new power relationship was established in society, say Barbosa & Specimille (2021). They also say that since then a debate has arisen about the impacts of media and social networks on users' mental health. Barbosa & Specimille (2021) warn that the pressure of exposure causes the user a tireless need

to fit into standards imposed by a media core, where they seek to assert themselves and be accepted by others.

And when "canceled" it can provide isolation, belonging, loneliness, hopelessness and psychological escape. Nunes (2019) argues that the use without self-restraint of the internet can trigger pathological triggers, with the emergence of conflicts that end up reverberating in more unbridled use of the internet and, he states, that mindfulness meditation can benefit this user from the damage caused by such behavior.

Generally, the altered state of consciousness can be related to Non-organic sleep disorders (F.51), Eating disorders (F.50), Personality disorders (F.60), Depressive episodes (F.32), and Neurotic disorders, Stress-related disorders, Somatoform disorders (F40-F.48), Narcissistic personality disorder (F.60.8), as stated in the International Statistical Classification of Diseases and Related Health Problems, the ICD – 10 (2000).

Laplanche & Pontalis (1998) explain that narcissism occurs in two moments, 'primary narcissism', when the baby invests all his libido in himself, and 'secondary narcissism', when his libido is invested in another and from him, he returns to his ego, promoting socio-affective interrelations.

Currently, babies and young children already have access to digital screens, often authorized by parents or guardians.

On the other hand, Lapa & Lacerda & Coelho (2016) demonstrate that through ICT (Information and Communication Technologies) and cyberactivism have gained relevance in the subjective formation of subjects, who have found other human and social meanings, therefore, they have become authors, producers and citizens of the digital universe. They also affirm that characteristics such as plurality, communicative action, translator dialogue, trust, collaboration, autonomy, permanent learner posture, creative and critical appropriation that demonstrated the emancipation of these user subjects in the virtual world.

From the 1950s, we return to Meerloo (1961/2009) who says that "the one who dictates and formulates the words and phrases we use, the one who is the master of the press and the radio is the "master of the mind", contextualizing this statement, if today we have the internet and Big Techs, and Organizations that control digital access such as Apple, Google, Amazon, Meta and Microsoft are the current masters of the mind.

Meerloo (1961/2009) launched the concept of *mentecide*, which refers to an organized system in which a tyrant transfers his own thoughts, ideologies, words and truths to the minds and mouths of the victims he intends to kidnap, which leads to *logocide*, which is the loss of the ability to reason freely, characterizing a "rape of the mind".

In this way, the role of digital influencers can also be questioned.

Since 2014, the adhesion to social networks has reached one billion users, so these networks have started to generate real effects on society, say Ferreira & Rios (2017).

They add that the owners of social media companies, search engines, browsers and websites have found a mine of the treasure, user data. Ferreira & Rios (2017) state that internet filters are tools that direct these users and that they are left without freedom of choice and, generally, do not perceive this condition.

The authors call this the "filter bubble", which encapsulates the user, by presenting him with what he likes, which does not always correspond to what he needs and this deprives him of the opportunity to test new ideas, products and information.

Hence, Ferreira & Rios (2017) say, the filter bubble effect leads the user to the "echo chamber", which is the constant repetition of something that the user subject already believed, through searches, exchanges of "opinions", "likes" and that through different ways and new navigations the same content emerges.

This is because algorithms record the data captured on the internet, social networks and search engines that keep the Internet user inside bubbles and this, by repeating insistently, produces the echo of information necessary to generate behaviors, opinions, feelings, among others, as previously described.

For this reason, the philosopher Véliz (2021) declares that privacy will be the most appreciated asset in the future, that Ethics on Artificial Intelligence (AI) should be used, as it stores the soul of users not in the sky of religion, but in the clouds.

In this way, Moraes & Testa (2020) declare that an Informational Ethics should be inserted to discuss the relationship between the human being and the digital technologies of the subject-connected-in-network. The etymological term of subject comes from the Latin *sub*, that which is below and *iacere*, placed, therefore, that which is subjected to some force.

The Philosophy of Mind, which investigates mind-body relationships, has vast material to propose debates that can expand the rationality about "Connected Virtual Narcissus", as it is the dimension between what is seen and what is felt.

In 2020, due to the quarantine and social isolation for the contingency of the Coronavirus, some behaviors became popular, the home-office, the home-office, entertainment, and interpersonal media relationships.

The tools for such work and social activity were smartphones, tablets, personal computers. In the use of these tools, the *imago* of the people appeared together with the *imago* of all those who were gathered in this meeting.

Some showed discomfort when they saw themselves all the time, often the participant's attention was linked to their own image. A type of concern appeared about their physical appearance, the environment-setting and about the noises inherent to the domestic environment that stood out all the time.

There have even been tools within devices to change the scenario behind you. But for some others, this condition was not a problem, people presented themselves online in a casual way, in typical environments of a house in the day-to-day routine, lying in bed, leaning over the living room or kitchen table, with people coming and going, swinging in hammocks, with domestic animals entering the scene.

In short, an unconditional novelty for both scenarios, there was no longer a clear distinction between the private and the collective, the public and the private, until the notion of time and the institution of the routine that it promotes was confused.

The traditional distinction between private life and public life is no longer significant.

They created applications that alter people's faces, putting on their *imago*, the appearance of animals, stars, symbols of the most varied, the distortion of the face and voice. Laughing at yourself, laughing at the other, changing the scenario, in short, would be a proposal for a joke to be able to deal with your image and endure it or just for fun, as with online games.

Also in 2020, with the murder of George Floyd, televised around the world, a worldwide debate was created about racism and in one of these debates he questioned the *Black Narcissus*, that is, how is the constitution of the subject and the self-esteem of an individual of black ethnicity in the face of so much adversity. By extension, one can think of 'white daffodil', 'yellow daffodil', 'trans daffodil', among other forms of 'daffodils' and the constitution of their self-esteem.

These related facts created a *thauma*, an astonishment, a curiosity to research the issue of the daffodil, as said, the constitution of a subject and his self-esteem associated with virtual, something potentially possible to accomplish, creating the concept 'virtual narcissus' connected to the internet.

This theme has moved a philosophical analysis about the self-image or mind of the Internet user and the possible relationships with his body-mind in navigation.

The Philosophy of Mind has the instruments to carry out this analysis and discussion, it has as its object of study precisely the mind-body relationship, thus allowing to obtain the necessary data to better understand the phenomenon in an interconnected world like today's.

Having as a basic reference the Myth of Narcissus, written by Ovid (43 BC – 17 AD) in the Hellenic period of Philosophy, which in addition to talking about self-love, provided the contemporary technical neologism, narcissism.

A classic human question that, contextualized for our days, finds coherent applications. Therefore, by naming it 'narcissism', it is intended to discuss issues such as 'body narcissism', 'moral narcissism', 'intellectual narcissism'. This demonstrates that we humans still have the same issues as in all the eras that have followed us, safeguarding the issues proper and inherent to their own era.

The phenomenon of the connected human is one of the main issues today, including the 'digital excluded' who still do not have access to the internet. This phenomenon, because it is still recent and because it has a very fast speed of updates and innovations, which sometimes there is no time to study them in depth, which in itself is already a problem, so fast that it is not possible to study them in the necessary depth, but it is already possible to observe their effects on society, in education, politics, geopolitics, economics, mental and physical health, among others.

Epistemology will still bring us qualitative and quantitative results about this human entangled in a virtual network. The Theory of Knowledge, in constant movement, will give us data on how the Internet user acquires knowledge from his principles of values, belief, truth and justification.

An observation of the nature of such a human condition can determine positive, negative, and blind points. Note that there is a lot of work for philosophers.

Some professional practices, such as teaching, clinical, philosophizing, governing, as well as some social practices, such as the formation of identity, ideological, religious, interpersonal, erotic, pornographic, and sexual groups have gained or assumed new spaces to exist in the virtual world.

In this way, the diversity of yesterday's ghettos gained today's public diversity to manifest itself, to exist, to appear, and that through a kind of rhizome found themselves connected to virtual networks and formed affinity groups that help each other. The cameras and microphones of personal mobile devices make up the new Agora in a virtual and globally connected world.

In such a short term, it is not yet possible to demonstrate how humans will absorb this new paradigm or how human relationships, such as mind-body, personal, interpersonal, social, work, political, ideological, religious, among others, will take place with the increase of Artificial Intelligence (AI).

On the other hand, some preliminary observations of this nature point to the risk of self-deception that involves from one's own appearance, by not recognizing oneself, through self-love, autoeroticism. Through the kidnapping of the mind, promoted by the 'masters of the mind', the Organizations that own the "domains" of the internet, commanded by Information Technology (IT), induce menticide and then logocide, is a probable risk. Generally these Organizations do not have any form of ethical, civil or governmental regulation.

It is also considered the permanence of the Internet user connected in a 'bubble' promoted by AI filters that leads him to the 'echo chamber'. A possible escape from the bubble and the echo chamber is to know the truth and obtain freedom under this condition. And this truth comes from the Philosophy that makes the connected human, philosophize on their own.

To this end, Plato's Allegory of the Cave can give us a relevant illustration, men kept looking at the bottom of the cave, saw only the reflections of what was presented to them, believed that this was the truth, they were deluded.

This is how a free mind will be, it will be one that recognizes its freedom and uses its free will to make free decisions and leave the captivity where it was kidnapped.

In some science fiction films, the 'future world', under the regency of the connection of things, robots, automation will be chaotic, dark, 'matrix' world, but the purpose of these films is to promote leisure and moments of entertainment and spaces for daydreams, promotion of sensations, but they do more than that, they provoke reflections.

Considering that series and 'streaming platforms', "data flows" and virtual games, as they promote an excess of entertainment, secreting in the body an "explosion of dopamine" that causes the feeling of pleasure and increases motivation, we see here the body-mind relationship. Therefore, nothing gloomy as in science fiction, but the warning sign has already been lit in some way.

In life, so-called real, there are already facts and evidence related to the connected human that must be researched and investigated, questioned, debated, regulated by rationality, as has been the philosophical tradition for millennia. It must be considered that one of the tasks of Philosophy is to 'futurar', that is, to observe the here-now in order to presume or infer routes to be created to arrive at a *telos* that brings happiness.

In the Myth of Narcissus, the young and handsome boy died of starvation due to toxic self-love when he found himself in the reflecting pool, confused by Echo. The question that currently arises about the 'virtual narcissus' is, by analogy, of the same magnitude, can the human be confused by the echo of the online connection and come to suffer from toxic self-love?

The dimension between what is seen in the virtual world and what is felt experiencing it in the physical world is attributed to the Philosophy of Mind.

2 THE POST-HUMAN

In the contemporaneity of a globalized and connected world, in which Information Technology and Automation have developed very quickly and in the face of a scenario in which Artificial Intelligence, as well as artificially produced organ or limb implants, the reality of robots and in the face of Automation Technology that is already enabled to make changes in DNA, Genetic Engineering places us in front of a new philosophical anthropology: the post-human.

As we innately inherit instincts and drives and in the face of this post-human "evolution", a question arises about how the relationship of parts implanted in the individual will take place and what will be the drive relationship of an individual with robots, what will be the relationship between the robots themselves, what identity of a post-human, what is the interference of Artificial Intelligence in this "new" non-Darwinian evolution. This is a real condition and one that must be focused on by the possible lights of Knowledge to understand it better.

Hawking (2018) asks: *"Will Artificial Intelligence surpass us?"*element. To this question, the author answers that intelligence is a central aspect of the human, from which arises everything that society has to offer. He says that intelligence comes from DNA and that DNA is incubated in transmitting it from generation to generation. The individual's sensory operations are stored in the brain or other systems to elaborate and perform functions. Hawking (2018) also states that it is in these "other storage systems" that they have become more intelligent and that in the evolved human they have produced consciousness.

In this sense, the author admits that computers can try to match or even surpass human intelligence or improve it, but they will never have a conscience, as this is an exclusive privilege of human beings who have neurons, neurotransmitters, hormones and a high-speed neuroelectric branch that the integrated circuits of machines will not be able to overcome.

Even though Hawking (2018) refers to Moore's Law that states that every eighteen months the speed of computers increases significantly, that this would demonstrate the 'self-evolution of humanity', since computers are designed and produced by humans, such a possibility is still small and remote.

He also believes that at a certain point Artificial Intelligence (AI) will find a way to surpass human intelligence and that AI itself will create itself without the help of humans.

In this regard, Philosophy will play a fundamental role in establishing the limits of AI, Philosophy of Mind and Computational Philosophy as well as Ethics will have to be ready on

this.

According to Hawking (2018), there are already economic sectors in which AI already makes decisions, plans, makes inferences, learns to manipulate machines used in industries and medicine such as those used by Neuroscience. However, he sees two issues with AI: general human-friendly benefits, but also potential unforeseen events if AI is no longer human-controlled. Therefore, he declares, there are already movements such as the European Parliament to regulate and control the creation of robots and AI itself.

Santos (2002) names this era "Post-Human", for this purpose, he says that the term is a neologism coined by Ihab Hassan, in the essay *Prometheus as Performer: Toward a Posthumanist Culture*, published in 1977, in Georgia Rewiew.

Santos (2002) cites the Nietzschean idea of the "superman", which is the being who, surpassing all values, would replace the last man through competition. Santos states that in the 1990s, due to the millenarian climate that led society to imagine that it was the end of History, some academics focused on this term, post-human, to demonstrate that techno-scientific, microelectronics, cyberculture, neuroscience and biotechnology developments were exerting a great impact on society. He states that the term post-human is still a term that has neither acquired density nor credibility as a descriptive or explanatory idea.

For the author, the term is a bet (SANTOS, 2002).

Santos (2002) also demonstrates that carbon (the basic element of biological life) and silicon (the basic element of microchips) are combining and promoting a revolution of the *cybernetic organism*, or cyborgs. In this way, ontologically, the being can become, the mixture of 'carbon with silicon' or 'protein with integrated circuit'. In other words, according to Santos (2002), this is a dialectical game, in which Materiality and Information are dialoguing more and more and faster.

The Age of Transhumanism is no longer a matter of science fiction, but a given fact.

For Teixeira (2010), due to the stagnation of man's evolution, due to his great distance from Nature, makes him couple himself to the world through the virtual, causing a new type of evolution mediated by equipment and machines. For Santos (2002), the human body, through the aging process, physically involutes, but Medicine, making use of Technology, has guaranteed methods for longevity to be extended. This is when hearts, kidneys, organs emerge that are machines created to help or even replace human tissue.

Teixeira (2010) states that implants of *integrated chips* and plates, such as organs printed in three dimensions (3D), can be called "parabiosis", where there is an association of the human through non-organic implants – becoming, finally, hybrid machines.

According to Teixeira (2010), in the near future cyborgs and robots will be among us humans in a natural way, overcoming the astonishment of the present day. For the author, the Post-Evolutionary world, in the virtual age, will have its own 'Philosophy' that can be formulated by the AI of robots and cyborgs themselves.

This is the Post-Human Era or Neurodigital Convergence (TEIXEIRA, 2010).

Teixeira (2010) demonstrates that machines can make us happier, and that parabiosis is not the realization of a utopia, but a technical and innovative evolution. In this sense, he continues, 'philosophy' itself may become extinct, since Robotic Epistemology may lead it to "extinction" – like the extinction of a species of Nature – in this case, the Philosophy of Science.

How will cyborgs have hybrid bodies, how will they express themselves, how will their personal identity be determined, and how will they experience personal experiences?

Also according to Teixeira (2010), the body needs to be conceived as a pre-linguistic entity and not a mere replication of the mind, the soul on a chip or in a program or application, via programming such as the behaviorist. In the post-human, the Philosophy of Mind is highlighted, and how it will manifest itself at this moment: just as a kidney can be replicated by a hemodialysis machine, in the future, the brain can also be replicated by some electronic device.

Following this reasoning, Tadeu (2000) says that human subjectivity today is a construction in ruins, since the "Masters of Suspicion", namely Marx (1818-1883), Freud (1856-1939), Nietzsche (1844-1900) and not to mention Heidegger (1889-1976), began their questioning. Since then, Philosophy has gained another contour. The author makes a provocation, through questions such as: "Do we still want to be subjects?" and "Who needs the subject?".

In this sense, Tadeu (2000) presents some cyborg technologies: a) Restoration of functions, replacement of lost organs and limbs; b) Normalizing, that is, creatures return to an indifferent normality; c) Reconfigurators, they create post-human creatures that are equal to human beings and at the same time different from them; d) Improvers, they create creatures that are better than the human being (TADEU, 2000).

In other words, according to Tadeu (2000), a paradox has been established, on the one hand there is the mechanization and electrification of the human, on the other, there is the humanization and subjectivation of the machine. It is precisely from the combination of these processes that the post-human creature emerges that will soon circulate among us naturally.

For Costa (2005), both Cartesian dualism and the monism of behaviorism do not clarify the Philosophy of Mind. In this way, the "mystery of consciousness" is the great metaphysical

problem of the Philosophy of Mind. Also according to the author (COSTA, 2005), the development of the Philosophy of Mind at this time is the greatest recorded in the last twenty centuries that preceded it.

Wittgenstein's work *"Philosophical Investigations"*, from the beginning of the 20th century, demonstrates this development. In this work, Wittgenstein, quoting Nestroy (known as the Austrian Shakespeare), says that "progress seems much greater than it really is" (WITTGENSTEIN apud COSTA, 2005, p.7).

This revolution, referring to the Philosophy of Mind Revolution, occurred as a reflection of other developments that began with the introduction of new methodologies of philosophical analysis and the emergence of new scientific domains, such as Neurophysiology/Neuroscience, Cognitive Psychology and Artificial Intelligence. And without a doubt Informatics (COSTA, 2005).

Costa (2005) also points out that, when neuroscience is able to explain how the brain works, what are the areas of the sensitive material or neurofunctional structure, such as sensations, perceptions, quasi-perceptual states, emotions, cognitions and conative states (and how from this explanation the "mobile center of egoity" is produced), then consciousness will become a mere physical property of biological matter. On this day – says Costa (2005) – the mystery of consciousness will disappear like smoke in the air.

Franco (2001) presents a new term, created in the 1980s, "Extropy", which has a meaning opposite to that of Entropy, this is the constant loss of energy tending to bankruptcy or extinction. According to Franco, Extropy challenges Entropy when it proposes a principle of limitless expansion of human life and consciousness. A part of this principle, the author explains, is the "transbiomorphosis", which is a discharge, or *upload*, of human consciousness into a computer chip that will enable the infinite perpetuation of life.

As in a synaptic connection between neurons, they are connected by electrical impulses in an integrated circuit, so using these electrical impulses, an individual's neurosynaptic information can be copied onto a silicon chip. That would be the complete replacement of meat *hardware* with biomechanical hardware. According to Franco, the adherents of the Extropian philosophy are in favor of any technology that preserves the advancement of longevity, of consciousness in the chip, in digital devices, of the body, which includes the *corpsicles*, which are those maintained by cryogenics in the hope of future reanimation – which for the author, are the so-called post-human bodies².

² FRANCO, E. S. The Manifesto of Extropian Art and the work PRIMO 3M+: Proposal for a Post-Human Body. Year 2001. **Compós: National Association of Graduate Programs in Communication**. Available: <http://www.compos.org.br/data/biblioteca_953.pdf>. Accessed on: 09 set. 2025.

Teixeira (2010) cites an article that Freud (1956-1937) wrote in 1919, for his friend Ferenczi (1873-1933), entitled *The Stranger*, in which he analyzes the short story by Ernst T.A. Hoffman (1776-1822), *The Sandman – The Sandman*, as an Aesthetic question – which is understood not as a simple theory of beauty, but as a theory of the qualities of sensation, of feeling, demonstrates the strangeness that the image of the sandman, an inanimate being that seemed animated, provoked in those who saw him.

According to Teixeira (2010), Freud, when analyzing Ernst T. A. Hoffman's short story, observed that people experienced a feeling of strangeness that generated doubts in the face of the automaton being, that it caused them the sensation of a "double", that is, of projecting onto the sand man, who seemed alive and possessed a soul, your own ego.

But at the same time, this *imago* demonstrated to the spectators that one day they would become mineral like him or that they would be overtaken by the 'sandmen'. This "double" demonstrates the narcissistic wound or frustration and impotence of the human being in wanting to perpetuate himself even if it is in a mass of silica, such as sand.

Clearly the question of death appears in this tale of the twentieth century. XIX and updated today with evidence of the innovations of the century. Therefore, according to Teixeira (2010), the fear in order not to become inorganic, is one of the human desires, to achieve immortality, even if it is in a post-evolved body, in a post-human body.

Finally, Tonetti (2008) considers that the terms "soul", "mind", "consciousness" and "spirit" are in the heart of philosophers and religious people, while the terms "brain" and "brain" continue to have more affiliates in the field of Science. With this argument, the author demonstrates that there is still a dualism, if not in the domains of human thought, there is at least a kind of methodological "dualism".

The Philosophy of Mind is the reflection on nature, on its essential properties, as well as the analysis of the cognitive capacities of the human, as well as discussing its properties, how the spirit, the soul and more recently the brain occur.

In the face of the current biotechnological revolution, the post-human revolution will change, alter, implement new characteristics in this brain-organ, altering the reflection we had of it until recently. This organ will be subjected to stimuli that it has never experienced.

A few years ago, before imaging exams, such as Magnetic Resonance Imaging and Computed Tomography and biochemical exams to understand hormonal functions and neurotransmitters, the human brain was studied through donated samples, that is, they were killed. Even so, several models of their functioning were inferred. Currently these image searches bring knowledge with the living person.

These assumptions have given Neuroscience new paths and it is sailing through seas never before navigated. From this arose the possibility of perfecting this organ-apparatus that turns human into an "I". Add to this Technology and Genetic Engineering, which from the mapping of the human genome, can do any reengineering in chromosomes, DNA's, such as CRISPR – gene editing, cloning and finally "creating" the new human being from stem cells in the laboratory. I call this *post-human evolution*, absolutely distinct from Darwinian evolution, which in the face of the scientific-technological advancement of laboratories, now looks more like a myth or a children's fable.

Is this an era of the New Enlightenment Revolution, a New Enlightenment?

But the vital energy, that innate force that drives the human along the paths of life to perpetuate the species, continues to manifest itself in each conceived being, whether naturally, *in-vitro*, by genetic engineering, by cloning. Life, regardless of the way in which it was generated, is inseparable from the being generated, Nietzsche's "will to power" is there and can be observed because it is a phenomenon and a manifestation of the spirit, the soul, the mind of this being.

After all, the opposite of death is birth and not life. There is no opposite to life.

In this post-modern, liquid world, there are already humans considered cyborgs, such as the first of them, Neil Harbisson, who since 2004 has received this condition in his English passport. It is worth mentioning here that a cyborg has an additional "sense organ" that is distinct from ordinary humans, the implant itself.

Currently there are robots making public services at corporate, judicial, commercial events, at concerts, there is even the United Arab Emirates, a female robot with a birth certificate and identity document.

The word robot comes from the Czech *robota*, which means 'forced labor' or 'slavery'. This term became popular after it was used in a play in 1920 whose title is R.U.R.; Rossum's Universal Robots by writer Karel Čapek (1890-1938), ³in the play were humanoid prototypes that performed heavy work and were not a carbon fiber machine like those of today.

For this reason, Ferrando (2023) says that the presence of the robot interferes with the current Culture and Imaginary and that technological transformations and the boundaries between human and machine are already part of the Post-Human Imaginary.

In the Post-Human, the question of the species and gender of robots will also be a theme of reflection in Philosophy. The question of the will to power in the post-human subject, in cyborgs, in robots, in artificial intelligence is an open question. The dawn of a new paradigm of

³ ČAPEK, Karel. R.U.R.: Rossum's Universal Robots. Critical edition. London: Penguin Classics, 2020.

human is emerging on the horizon of the twenty-first century.

What will be the questions of Philosophy in the face of this *contemporary* thauma?

3 PHILOSOPHICAL ADVICE: FROM ANCIENT GREECE TO THE PRESENT DAY

The year 2020 began with a serious health threat, a lung infection of unknown origin that manifested itself in December 2019 in a market in the province of Wuhan in China that soon became the COVID-19 pandemic. In this scenario, humanity plunged into an existential crisis, fear, insecurity, anxiety, depression, and the expectation of an immunizer. Human existence has been threatened and self-care has become a priority.

The issue of the pandemic accelerated the massive use of devices connected to broadband internet that connected all people who had access to a Wi-Fi network, an advanced technology already available at the time that eased the anguish of the moment. A real malaise in civilization.

The malaise of civilization was an ideal moment for philosophers to act with Philosophical Counseling, which with its practices gave meaning to existence and helped many to adjust and alleviate the existential and emotional suffering of that 'new reality', of the old 'new normal'. Those who sought consolation in Philosophy, in addition to finding it, began to philosophize on their own.

Regarding the performance of philosophers, the Brazilian Classification of Occupations – CBO, instituted by ministerial ordinance no. 397, of October 9, 2002, aims to identify occupations in the labor market, for classification purposes with administrative and household records. The description of the activity of graduates in Philosophy is in Code 2514-05:

They critically and systematically reflect on the being and destiny of man and the world, through the assimilation of the classics of thought and the realization of research on philosophical themes, such as ethics, epistemology, aesthetics, ontology, metaphysics, politics, logic, culture, among others, with the purpose of *training* and *guiding* people and *advising* organizations. (CBO, 2002)

Therefore, graduates in Philosophy can work in spheres such as Philosophical Guidance, Philosophical Counseling, Clinical Philosophy, Therapeutic Philosophy, Philosophical Dialogue, Philosophical Coaching, Philosophical Mentoring, Medicine of the Soul, Philosophical Analysis both in the Personal and Organizational spheres. For this Theoretical Philosophical Essay, the term Philosophical Counseling (FA) will be used.

3.1 THE EVOLUTION OF THE CONCEPT OF "I"

From Ancient Greece we inherited the universal concept, psyche, which is the conception of a consciousness or soul, as Abbagnano (2018) demonstrates. According to Abbagnano (2018), the concept of psyche was translated into Latin as soul and expresses the principle of life, sensitivity, and spiritual activities that constitute an entity in itself.

Teles (1974) states that each one should have their own philosophy of life or a worldview, the *weltanschauung*, from the German *welt* = world and *anschauung* = vision, which can be *optimistic, pessimistic, conservative, progressive, retrograde, advanced, motivating or inhibiting, among others*.

For Teles (1974), having one's own philosophy of life indicates that each one attributes their own meanings to their personal experiences. The same author clarifies that the mythical phase is a primitive narrative explanation to explain an existential function of man to give him existential meaning, by analogy each man has his mythical phase that specializes throughout his life, expanding or not his worldview.

In Ancient Greece, what is called the miracle of rationality occurred, as follows:

Two main motives have concurred in leading man from mythical to rational thinking: first, the contradictions of mythical thought, and secondly, the natural strengthening of reason, which has come to be exercised in more critical terms. (TELES, 1974, p. 19).

From the emergence of reason in more critical terms and about everyday life, Chauí (1999) clarifies that man asks questions, makes statements, evaluates things, people and himself. According to Chauí (1999) these questions and statements silently contain *unquestioned beliefs*, thus concepts such as truth, thought, procedures, relations between theory and practice and accumulation of knowledge are philosophical questions.

Abbagnano (2018) adds that the pronoun "I" is the way in which man designates himself and that this pronoun has become the object of philosophical investigation.

For philosophical research, Franca (1987) argues that one should follow human thought in the different phases of its Knowledge, in the different eras or epochs, and inventorying the efforts and attempts of intelligence, the questions of the universe and the vision of man throughout Philosophy, from Ancient Greece to the present day.

Therefore, Philosophical Counseling can contribute to the querent so that he leaves his phase of myth or unquestioned beliefs and reaches his rational phase, of knowing himself or reflecting on himself.

3.2 HEALING BY THE RATIONAL WORD

Smolka (1972) says that in the cultural and religious tradition of Ancient Greece there was a pilgrimage to the Oracle of Delphi. Souza (1992) clarifies that in the oracle a querent receives a divine message or answer to a consultation, by extension, it refers to a sanctuary in which sacrifices and questions are made to the gods through a priest, who is also responsible for bringing the answer to the requesting querent. Souza (1992) also clarifies that the word oracle retains its double meaning of "means or instrument to speak" with a god and "brief oral response" of this god through the priest.

By analogy, the oracle is the space from which the Counseling takes place, the querent is the one who wants or needs to know himself and the priest is the philosopher.

Fossatti (2003) adds that in this period, the sixth century BC, it was common for any Greek citizen or foreigner to go for advice at the Temple of Apollo in Delphi, where the inscription in Greek, *Know thyself*, is written. Fossatti (2003) explains that such inscription was a warning to the oracle's consultants, as it aimed at the purification of the soul through the individual's speculative knowledge about himself.

However, Smolka (1972) says that this attitude was mystical.

Teles (1974) demonstrates that he was the pre-Socratic philosopher of the twentieth century. V BCE, Empedocles of Agrigento (494-430 BCE), the first to consider two abstract human principles in addition to reason. These principles are *love* and *struggle*, both would be responsible for the union or disintegration of the primordial elements: earth, air, water and fire.

According to Teles (1974), Empedocles of Agrigento conceived that all compound substances are short-lived, like matter, and that only the four primordial elements and the two principles are eternal because they are precisely simple.

Forghiere (2007) adds that it was Empedocles of Agrigento who was the first philosopher to use words or counseling as a treatment for the ills of the soul, he was the first to deal with abstract human issues, not considering them as a merely physical element.

Franca (1987) also admits that Empedocles da Agrigento conceived the soul as composed of the four elements and the two principles, this would explain the possibility of the human seeking knowledge, since the soul, through cognition, learning through the sense organs and experience, can copy nature and apprehend it for itself.

Ghiraldelli Jr (2012) says that in the phase of Socrates (470-399 BC), he practiced maieutics, that is, giving birth to ideas, leading people to think of themselves and about themselves, to make an examination of their lives.

What Ghiraldelli Jr (2012) calls "the medicine of the soul", says that Plato (428-348 BC) considered that the soul was improved through love, *eros*, therefore erotic. According to Ghiraldelli Jr (2012), Aristotle (394-322 BC) when talking about the 'good city', the polis, brought in its context the concept of "quality of life".

It was only with the Hellenic philosopher Epicurus (341-279 BC) that the 'medicine of the soul' became something close to medicine, that is, treating through a therapy of the psyche, with the tetrapharmaco, declares Ghiraldelli Jr (2012).

For Chaufí (1999), in the Hellenic period, the Stoic philosophers only considered the body, even the soul was only corporeal, they were monists, whose relationship with the 'real object' needed logic to apprehend its meaning and significance.

In the phase of Modern Philosophy, Blaise Pascal (1623-1662 AD) in his posthumous work *Thoughts* of 1670 considers, in the midst of the rationalist movement, that reason should be based on the 'knowledge' of the heart and on the 'instincts' as follows, *the heart (intuition) has reasons that reason itself does not know*.

For Ghiraldelli Jr (2012), Rousseau (1712-1778 AD) already called alienation the 'disease of the soul', well before Karl Marx (1818-1883 AD) and for Foucault (1926-1984 AD) the soul imprisons the body by social conditioning.

Ghiraldelli Jr (2012) states that Philosophy was born as the "medicine of the soul".

Who has a sick soul? Is there a special medicine for those with a sick soul? [...] The medicine of the soul was born as Philosophy. There are those who even go so far as to say that Philosophy was truly born as a medicine of the soul. (GHIRALDELLI JR, 2012, pg. ix).

3.3 SOME CONTRIBUTIONS OF NEUROSCIENCE TO PHILOSOPHICAL COUNSELING

Tieppo (2019) demonstrates that Neuroscience began in pre-Socratic Greece when two currents of thought were in force, one of the philosophical currents said that the soul was located in the heart, the other, however, said that the soul was located in the brain, the encephalocentrists, whose exponent was Hippocrates of Kos (460-370 BC), who was later followed by Plato.

Tieppo (2019) also demonstrates that it was Renè Descartes (1596-1650 AD) who paved the way for the systematic study of the brain organ, when he stated the differences between substances, the *res cogitans* (mind) and the *res extensa* (body), the body that thinks. However, the brains were of the dead. Tieppo (2019) clarifies that it was only in the late 1980s, with the beginning of neuroimaging, that there was a revolution in the understanding of brain functions *in vivo*. For this reason, the 1990s are called the "Decade of the Brain".

So, currently, given the degree of knowledge of brain processes, Neuroscience goes beyond studies of brain pathologies and focuses on the investigation of the mind, consciousness, the unconscious, emotions, and human behavior, mapping the brain, says Tieppo (2019).

For Tieppo (2019), Neuroscience denies the existence of the mind as immaterial and recognizes that mental processes are the result of our Central Nervous System (CNS), therefore, they are the result of electrical impulses in neurons and, thus, it is monistic.

From Neuroscience, Goleman (2012) states that Emotional Intelligence is a powerful model for education in the form of emotional, social, professional, I would say also philosophical, being an active agent in a full life and that took advantage of the "Decade of the Brain" to create this new concept, Emotional Intelligence. Goleman (2012) structured a new Field of Knowledge: Affective Neuroscience.

Goleman (2012) says that, in his research, he made discoveries of certain areas or regions of the brain involved in self-awareness that help us with ethical issues and decision-making, the Neocortex, the Thinking Brain. Goleman (2012) says that self-mastery requires self-awareness and self-regulation, these are fundamental components of Emotional Intelligence.

The activation of the Prefrontal Cortex is essential for self-regulation and is considered by Goleman (2012) as the "good boss" of the brain, as it guides us to the best of us. The *cerebral amygdala*, both on the right and left sides, are the brain's radar for threats, it is the point at which anguish, anger, impulsivity, fear are triggered and when this circuit "takes" the command it starts to act as the "bad boss", leading the human to take wrong attitudes.

When the Prefrontal Cortex is dominated by the cerebral amygdala, what Goleman (2012) calls "amygdala hijacking" occurs.

The amygdala is the brain's radar for threats. Our brain was designed as a survival tool. In the sole of the brain, the amygdala holds a privileged position. If it detects a threat, in an instant it manages to dominate the rest of the brain—particularly the prefrontal cortex—and we have what's called amygdala hijacking. Hijacking captures our attention, projecting it onto the ongoing threat. (GOLEMAN, 2012, pg. 39).

In order for this hijacking of the cerebral tonsils not to occur, the person must be attentive and alert about the possible hijacking and, through the activation of the Prefrontal Cortex, not lose balance, says Goleman (2012). By knowing oneself and learning to reflect on oneself using the tools of Philosophy, it is equivalent to having a predominance of the Prefrontal Cortex.

It is a conscious choice, therefore, teachable, to maintain the predominance of the prefrontal and, thus, inhibit the "short temper" action of the tonsils, says Goleman (2012). To

maintain control of the prefrontal, Goleman (2012) suggests some efficient "choices", such as mindfulness, motivation, self-awareness, empathy, mindsight, optimal performance, that is, maximum use of the brain, with emotional learning.

Regarding the convergence between Philosophy and Neuroscience, *Neurophilosophy*, Fischer and Facion (2011) propose a question, "a new image of a person?", thus opening a debate on the new "I", on brain determinism, on the constitution of free will, on neuroethics, undoubtedly a field of Philosophical Anthropology.

3.4 THE PRACTICE OF CURRENT PHILOSOPHICAL COUNSELING

It was in 1981 that the German philosopher Gerd Achembach proposed Philosophical Counseling as a practice of a Philosophy that was not Academic, not restricted to intellectual debates, but that reached ordinary people, with their existential needs, Pechula (2007) clarifies.

Nardi (2017) when presenting the method of Philosophical Counseling cites Immanuel Kant (1724-1804 AD) who recommended that one should teach to philosophize and not to teach about Philosophy, in this way he approaches the Socratic method, of leading the advised to give birth to their own ideas.

For this reason, Pechula (2007) adds that current Philosophical Counseling goes back to its true origin in Ancient Greece, where there was the "philosopher therapist", the "doctor of the soul" or the "philosophical advisor", this current found repercussion with Marc Sautet in France, with Lou Marinoff in the United States, with Lúcio Packter and the Research Group in Applied Philosophy (GPFA) of Claretiano/CNPq in Brazil.

Achembach (2006), in addition to being a pioneer of the current Practical Philosophy movement, explains that Philosophical Orientation is a philosophy focused on life and that it is currently an alternative to psychotherapies, since it is for people who do not feel bad enough to consult with psychotherapists, but that it is for those who have the impression that their real life does not correspond to their existential expectations and who want to reflect about their vital circumstances, which they want and desire to understand and be understood.

Oliveira (2014) says that Ran Lahav illustrated, based on Plato's Allegory of the Cave, that the objective of Philosophical Practice is to provide rational and emotional conditions for the practitioner to leave his cave and see the "light".

Ran Lahav shows through Plato's allegory of the cave that the goal of philosophical practice will not be to "make life in the cave more comfortable", but to "get out of the cave". However, we have to understand "our cave" in order to "get out of it". This is the process that philosophical practice must operate: "mapping the cave". It is necessary,

according to Lahav, to understand our cave: the emotional and rational "perimeter" of action in life. (OLIVEIRA, 2014, ed. May/2014).

Menezes (2011) demonstrates that Philosophical Counseling, in the sense of a specifically philosophical application, is available to help, to guide the individual in his personal relationship with himself.

For Marinoff (2012), people always knew that Philosophy was good for something, but they could not explain exactly what for. Everyone has a philosophy of life, but few have the possibility to analyze their own life and even form their own philosophy throughout it, ponders Marinoff (2012).

The philosophical practice of Philosophical Counseling can be carried out in two formats, Marinoff (2012) clarifies that in the first it is in an Individual way as in the counseling itself and in the second it is in a Group way as in the Socratic Dialogues, in the Philosophical Cafés and in the Organizations.

Marinoff (2012) also clarifies that philosophical analysis means dividing the concept into its parts, as simple as possible, in order to reveal the logical structure contained in these fragments.

About Freedom, Abbagnano (2018) states that "Epictetus said that *the things that are in our power were free*, that is, the acts of man that have a beginning in man himself". In other words, "knowing oneself" is in the sphere of one's power and has a principle in oneself. By inference, I affirm that "*Freedom emancipates man by nature*" (Sérgio Máscoli, 2026).

About Logic, Abbagnano (2018) demonstrates that it is a set of coherent statements, where each part or fragment of the analyzed statement is true, and that when a part of the statement is false, then there is a fallacy, where every argument is false. For Nardi (2017), the use of reason to intervene in the problems that a person faces requires him to adopt a *rationalist philosophy* and abandon his own irrational beliefs, without logical reason or his myths with the support of the philosophical advisor.

Philosophical Counseling, although it may seem, is not a recent practice. Philosophy was born *as a counselor*, whose starting point is *thauma*, astonishment and admiration, not only about *physis*, nature, but also about the human being, his stay and his life in the world over time.

Man, in the same way, can change his impressions and his ideas, while remaining the same ego. [...] Unity is neither absolute nor rigorous: it is formal and approximate, founded on the relative constancy of certain relations between the parts or moments of the self. (ABBAGNANO, 2018, pg. 454).

Philosophy formulates questions, therefore, it is a listener of the answers it receives and thus, through dialogue, reflection arises, knowledge always open to the human as well as to Philosophy itself. After all, Philosophy glimpses the eternal newness of this world.

The *polis* represented the apex of Greek civilization and by a *polis* one can understand the collective of humans: men, women, children, slaves or foreigners, even if only men born in Athens were recognized as free citizens.

However, everyone wanted to know their destiny and what route was reserved for them. And in a search to know the purpose of their existence, oracles emerged, where gods were consulted through a priest, who was still a "philosopher", who brought the querent answers to his questions.

With the passage of time, the oracle became the Agora, the latter became the Confessional, the latter became the Chair and the latter became Radio and TV, the latter gained a personal camera and microphone and, finally, these became the World Wide Web, the Internet.

All thanks to the advances in Technology and Innovation, rudimentary and mystical in the beginning and now highly specialized, in which the figure of the philosopher and his rational advice become increasingly essential for the prevention of damage and for the logical contingency of personal, institutional, business and organizational exaggerations.

This technology has made Neuroscience clarify that the rationally chosen control of the cerebral *amygdala* by the activation of the Prefrontal Cortex, is equivalent to rational Stoic sapiential practices, where the attribute of a great soul or reason is to have calm, tranquility, stress control and look with pride at the difficulties imposed on the human, resilience.

At a time when humanity was faced with its own fragility and finitude, the becoming, in short, of existential questions, it became necessary to act as Philosophical Counseling and now this practice is becoming increasingly popular.

Therefore, the philosophical practice of Philosophical Counseling, a Field of Knowledge, represents throughout its journey an invitation to the human being to examine himself, to know his subjectivity, to recognize himself, to seek his *eudaimonia*, his *good spirit*, in other words, his happiness which is "walking towards wisdom", "being a friend and lover of wisdom", Only then will its existence have been worth living in this globalized and interconnected world.

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3D HUMANOID CHARACTERS IN AUGMENTED AND VIRTUAL REALITY: DEVELOPMENT OF IMMERSIVE ENVIRONMENTS AND EVALUATION OF THE PERCEPTION OF THE UNSTRANGE VALLEY

PERSONAGENS HUMANOIDES 3D EM REALIDADE AUMENTADA E VIRTUAL: DESENVOLVIMENTO DE AMBIENTES IMERSIVOS E AVALIAÇÃO DA PERCEPÇÃO DO VALE DA ESTRANHEZA

PERSONAJES HUMANOIDES 3D EN REALIDAD AUMENTADA Y VIRTUAL: DESARROLLO DE ENTORNOS INMERSIVOS Y EVALUACIÓN DE LA PERCEPCIÓN DEL VALLE NO EXTRAÑO



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ABSTRACT

With the advancement of immersive technologies and the growing use of humanoid characters in digital games, simulations, training systems, and educational applications, it becomes necessary to understand how different visualization modes influence users' perception of these characters. This paper presents the development of augmented reality and virtual reality environments to evaluate the perception of the Uncanny Valley in 3D humanoid characters with facial and body movements. The study compares three visualization conditions: computer monitor, virtual reality headset, and augmented reality headset. The methodological approach is quantitative, using Likert-scale questionnaires and statistical analysis through one-way ANOVA and Tukey post-hoc tests. The results indicate that the type of display influences the perception of similarity, strangeness, likability, presence, and movement naturalness. Immersive devices tend to attenuate perceived strangeness, whereas computer monitors tend to intensify perceptual discomfort in characters with facial and body movements. The augmented reality headset presents favorable performance in the perception of similarity and likability, while the virtual reality headset stands out in measures associated with presence and naturalness under specific conditions. It is concluded that the development of humanoid characters for immersive media should consider not only visual realism, but also the type of display and the dynamic naturalness of movements.

Keywords: Uncanny Valley. Virtual and Augmented Reality. Facial and Bodily Movements. Humanoid Characters. Perception.

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RESUMO

Com o avanço das tecnologias imersivas e a ampliação do uso de personagens humanoides em jogos digitais, simulações, treinamentos e aplicações educacionais, torna-se necessário compreender como diferentes formas de visualização influenciam a percepção desses personagens. Este artigo apresenta o desenvolvimento de ambientes de realidade aumentada (RA) e realidade virtual (RV) para avaliação da percepção do Vale da Estranheza em personagens humanoides 3D com movimentos faciais e corporais. O estudo compara três condições de visualização: monitor de computador, capacete de realidade virtual (HMD-RV) e capacete de realidade aumentada (HMD-RA). A proposta metodológica adota abordagem quantitativa, com coleta de respostas por questionários em escala Likert e análise estatística por ANOVA de um fator e testes post-hoc de Tukey. Os resultados indicam que o tipo de display influencia a percepção de semelhança, estranheza, simpatia, presença e naturalidade dos movimentos. Observa-se que os dispositivos imersivos tendem a atenuar a estranheza percebida, enquanto o monitor de computador apresenta maior tendência a intensificar o desconforto perceptivo em personagens com movimentos faciais e corporais. O HMD-RA apresenta desempenho favorável na percepção de semelhança e simpatia, enquanto o HMD-RV se destaca em medidas associadas à presença e naturalidade em determinadas condições. Conclui-se que o desenvolvimento de personagens humanoides para mídias imersivas deve considerar não apenas o realismo visual, mas também o tipo de display e a naturalidade dinâmica dos movimentos.

Palavras-chave: Vale da Estranheza. Realidade Virtual e Aumentada. Movimentos Faciais e Corporais. Personagens Humanoides. Percepção.

RESUMEN

Con el avance de las tecnologías inmersivas y el uso cada vez mayor de personajes humanoides en juegos digitales, simulaciones, capacitación y aplicaciones educativas, resulta necesario comprender cómo las diferentes formas de visualización influyen en la percepción de estos personajes. Este artículo presenta el desarrollo de entornos de realidad aumentada (RA) y realidad virtual (RV) para evaluar la percepción del Valle Inquietante en personajes humanoides 3D con movimientos faciales y corporales. El estudio compara tres condiciones de visualización: monitor de computadora, casco de realidad virtual (VR-HMD) y casco de realidad aumentada (AR-HMD). El enfoque metodológico adopta un enfoque cuantitativo, con recopilación de datos mediante cuestionarios de escala Likert y análisis estadístico mediante ANOVA unidireccional y pruebas post-hoc de Tukey. Los resultados indican que el tipo de pantalla influye en la percepción de similitud, extrañeza, simpatía, presencia y naturalidad de los movimientos. Se observa que los dispositivos inmersivos tienden a atenuar la extrañeza percibida, mientras que el monitor de computadora muestra una mayor tendencia a intensificar la incomodidad perceptiva en personajes con movimientos faciales y corporales. El HMD-AR muestra un rendimiento favorable en la percepción de similitud y simpatía, mientras que el HMD-VR destaca en medidas relacionadas con la presencia y la naturalidad bajo ciertas condiciones. Se concluye que el desarrollo de personajes humanoides para medios inmersivos debe considerar no solo el realismo visual, sino también el tipo de pantalla y la naturalidad dinámica de los movimientos.

Palabras clave: Valle Inquietante. Realidad Virtual y Aumentada. Movimientos Faciales y Corporales. Personajes Humanoides. Percepción.

1 INTRODUCTION

The creation of 3D humanoid characters occupies a central position in different fields of contemporary digital media, especially in digital games, VR environments, AR applications, simulations, training, and experiences associated with the metaverse (MYSTAKIDIS, 2022). As these characters visually approach human beings, users' expectations for the naturalness of their behaviors, expressions, and movements are expanded. However, the partial approximation of human realism can produce a negative reaction known as the Valley of Strangeness, a phenomenon in which quasi-human entities provoke discomfort, restlessness or perceptual rejection (MORI; MACDORMAN; KAGEKI, 2012).

The challenge is not limited to visual appearance. In digital environments, humanoid characters are not only observed as static images; They talk, walk, blink, direct their gaze, gesticulate, and in some cases approach the user in virtual or augmented space. In this way, facial and body movements become decisive elements for the perception of naturalness, since visual and movement factors can directly interfere in the evaluation of virtual characters (JIANG et al., 2022). Small inconsistencies in the gaze, lip synchronization or body can break the illusion of presence and accentuate the feeling of strangeness, especially in immersive experiences in which the incorporation and perception of the virtual body are more sensitive (LUGRIN; LATT; LATOSCHIK, 2015). On the other hand, movements perceived as natural can contribute to greater acceptance, sympathy, and perceptual comfort.

The literature on the Valley of Strangeness is extensive in studies with static images, robots, virtual agents or characters visualized on monitors. However, there are still gaps when considering 3D humanoid characters in motion, evaluated on different displays and, especially, in augmented reality environments. Previous studies indicate that the type of display can alter the perception of avatars and digital characters, especially when comparing monitors and helmets (HMDs) (HEPPERLE et al., 2022; SEYMOUR et al., 2021; YAN, 2019).

The use of HMDs alters the spatial relationship between user and character. On the monitor, the experience takes place in a two-dimensional window far from the user's body; in HMD-VR, the user is transported to a digital environment; in HMD-RA, the virtual character is perceived as superimposed on the physical space. This difference can modify the way the character is perceived.

In this context, this article presents the development and evaluation of immersive environments to investigate the perception of the Valley of Strangeness in 3D humanoid characters with facial and body movements. The proposed cut focuses on the relationship between the type of display, the naturalness of the movements and the perception of the

characters. The research compares three visualization technologies: computer monitor, HMD-VR and HMD-RA. The variables evaluated include human likeness, strangeness, sympathy, presence and naturalness of eye, lip, body and combined movements.

The objective of the article is to analyze how different displays influence the perception of 3D humanoid characters, considering the construction of controlled environments, the presentation of characters with specific movements and the collection of subjective responses through numerical scales. The main contribution is to articulate technological development and perceptual evaluation, offering subsidies for projects that use humanoid characters in immersive media, digital games, training, education and interactive communication.

2 VALLEY OF STRANGENESS, HUMANOID CHARACTERS AND IMMERSIVE DISPLAYS

The Valley of Strangeness is usually associated with the hypothesis proposed by Mori in 1970, according to which human affinity for robots or artificial entities tends to increase as human resemblance grows, until a region of discomfort arises when the entity becomes almost human, but still has noticeable imperfections (MORI; MACDORMAN; KAGEKI, 2012).

The discussion about the uncanny, however, precedes the formulation of the concept in the field of robotics, appearing in studies on uncertainty in the face of apparently animated objects or quasi-human figures since the beginning of the twentieth century (JENTSCH, 1997; FREUD, 2017). In later translations and revisions, the phenomenon is discussed with terms such as strangeness, sympathy, familiarity, and affinity, used to describe different emotional responses to humanoid figures (KÄTSYRI et al., 2015). These constructs also appear in measurement instruments aimed at evaluating robots and humanoid agents, such as the Godspeed scales and later derivations (BARTNECK et al., 2009; HO; MACDORMAN, 2010; HO; MACDORMAN, 2017).

This phenomenon is particularly relevant in the development of virtual characters, as human realism is not evaluated only by appearance. Skin texture, facial proportions, look, expression, posture, gesture, speech, and synchronization between sound and movement make up a perceptual set. When there is inconsistency between these elements, the user may perceive the character as artificial, disturbing, or uncomfortable. The problem becomes more sensitive in humanoid characters because the observer has a refined perceptual repertoire to identify subtle deviations in human faces and bodies, especially in facial and movement features (JIANG et al., 2022).

In static characters, the strangeness can stem from visual features such as blurred eyes, rigid facial expression, or ambiguous anatomical proportions. In animated characters, the field

of evaluation expands. Eye movement may suggest attention, social contact, or avoidance; the lip movement needs to maintain coherence with speech; Body movement needs to follow the weight, balance and intention of the action.

Thus, movement can both reduce and intensify the Valley of Strangeness, since the original hypothesis already distinguishes responses to static and moving entities (MORI; MACDORMAN; KAGEKI, 2012). A visually simple but well-animated character may be more acceptable than a realistic character with incoherent movements.

Immersive displays add another layer to the problem. VR promotes isolation from the physical environment and construction of presence in a digital space (BURDEA; COIFFET, 2003; SLATER; SANCHEZ-VIVES, 2016). AR, in turn, preserves the physical space and inserts virtual objects on top of it, creating a hybrid experience (AZUMA, 1997; AZUMA et al., 2001).

This relationship can be understood in the reality-virtuality continuum, in which AR and augmented virtuality occupy intermediate positions between the real and the virtual (MILGRAM et al., 1995).

When a humanoid character is observed in AR, he begins to dispute perceptual coherence with the real world. Its scale, position, lighting, distance, orientation and spatial registration become fundamental, as the alignment between virtual object and physical environment is a central requirement of AR applications (TORI; HOUNSELL; KIRNER, 2018).

In VR, according to the same authors, coherence depends on the stability of the virtual environment, the quality of rendering and the response to the user's movements. On the monitor, observation tends to be more distanced, but also more critical of isolated visual details.

Therefore, the perception of the Valley of Strangeness in 3D humanoid characters depends on a composition of factors: level of realism, naturalness of movements, spatial context, type of display, sense of presence, and user expectation. The analysis of these factors is necessary to guide the development of characters intended for immersive and non-immersive environments.

3 DEVELOPMENT OF IMMERSIVE ENVIRONMENTS

3.1 GENERAL PROJECT STRUCTURE

The experimental design was designed to allow the controlled presentation of 3D humanoid characters in three viewing conditions: computer monitor, HMD-VR and HMD-RA.

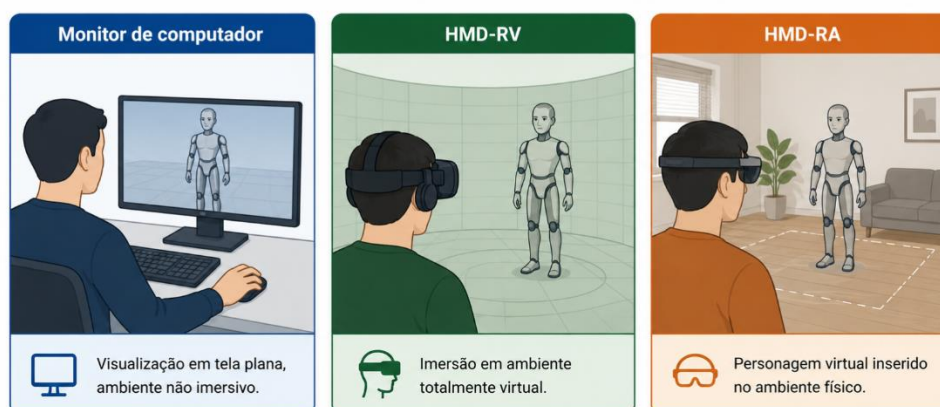
The technological framework was developed with a focus on standardizing the experience and reducing external interference during data collection. To this end, environments capable of presenting the characters, guiding the participant, collecting responses, and

recording the necessary information for later analysis were implemented, following the need to control the type of display in studies on avatar perception and the Valley of Strangeness (HEPPERLE et al., 2022; YAN, 2019).

The adoption of three displays allows you to compare different levels of immersion. On the computer monitor, the participant observes the character on a two-dimensional screen and interacts through conventional peripherals. In HMD-VR, the participant visualizes a complete virtual environment, with the character positioned in three-dimensional space. In HMD-RA, the character is superimposed on the physical environment, so that the user perceives the virtual entity integrated into the real room. Figure 1 outlines the difference between these three types of viewing conditions used in this study.

Figure 1

Visualization conditions used in the study



Source: prepared by the authors.

The comparison between these conditions, as seen in Figure 1, allows us to observe whether immersion and spatial integration alter the perception of similarity, strangeness, sympathy and naturalness, considering the conceptual differences between VR and AR (BURDEA; COIFFET, 2003; AZUMA, 1997; AZUMA et al., 2001). Table 1 summarizes the three visualization conditions adopted in the study, differentiating them according to the type of experience, the environment perceived by the participant and the general form of interaction.

Table 1

Summary of the evaluated viewing conditions

Condition	Type of experience	Perceived environment	General form of interaction
Monitor	Not immersive	Virtual environment viewed on a 2D screen	Mouse and conventional interface

Condition	Type of experience	Perceived environment	General form of interaction
HMD-RV	Immersive	Fully virtual environment	HMD-VR and Controls
HMD-RA	Augmented Immersive	Physical environment with overlapping virtual character	HMD-RA and controls

Source: prepared by the authors.

In Table 1, it is noted that the condition with a monitor corresponds to the non-immersive experience, in which the character is observed on a two-dimensional screen and the interaction occurs through a mouse and conventional interface. The HMD-VR condition, on the other hand, is characterized as an immersive experience in a totally virtual environment, using a virtual reality helmet and controls. In turn, the HMD-RA condition is also immersive, but based on the overlay of the virtual character on the physical environment, allowing the participant to perceive the presence of the character in real space through the augmented reality helmet and its controls.

Thus, Table 1 shows that the three conditions differ not only by the equipment used, but also by the degree of immersion and the spatial relationship established between participant, environment and 3D humanoid character.

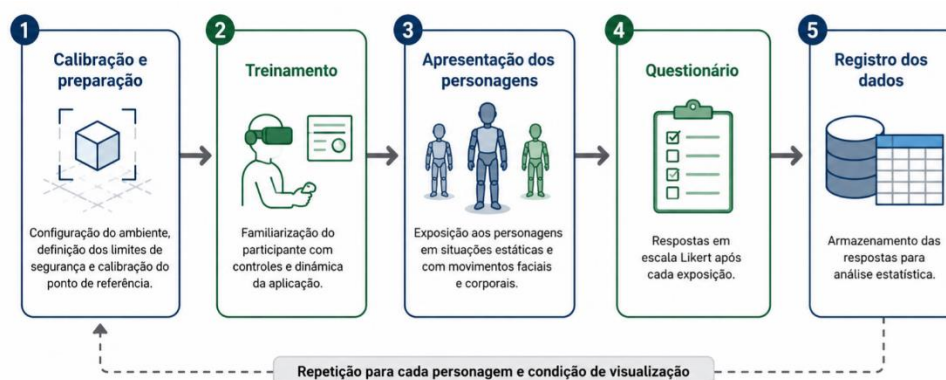
3.2 VR AND AR ENVIRONMENTS

The VR environment was structured to minimize distracting stimuli. The virtual room has a neutral configuration, with control over the participant's position, distance from the character and lighting. This methodological choice seeks to prevent external elements from influencing the character's evaluation. The display experience uses similar logic, preserving the virtual scene and adapting navigation for non-immersive viewing.

In the AR environment, the physical space is part of the experience. For this reason, a calibration stage was necessary to define the reference point at which the characters would be presented. Calibration allows you to position the character in a stable and coherent place, preventing your virtual presence from conflicting with physical obstacles or elements of the room.

The calibration procedure is particularly important in AR, as registration failures can compromise the perception of naturalness and increase strangeness, since spatial registration is one of the central elements for the coherence of the augmented experience (AZUMA, 1997; TORI; HOUNSELL; KIRNER, 2018).

Figure 2 shows the overall structure developed in the AR and VR applications.

Figure 2*General structure of the experimental procedure*

Source: prepared by the authors.

The general structure of the environments presented in Figure 2 includes, in sequence, a calibration scene, a training scene, character presentation scenes and a questionnaire scene. This organization allows the participant to understand the form of interaction before the main assessment. The training scene uses simple questions and basic objects, reducing the risk that operational difficulties with the device contaminate the perceptual responses about the characters.

3.3 HUMANOID CHARACTERS AND MOVEMENTS EVALUATED

The 3D humanoid characters were organized into different levels of human likeness, ranging from clearly artificial or robotic shapes to characters with greater visual proximity to the human body. This diversity allows us to observe the perception of the participants at different points of the spectrum associated with the Valley of Strangeness, according to the relationship between human similarity and affinity proposed in the literature (MORI; MACDORMAN; KAGEKI, 2012; KÄTSYRI et al., 2015). The proposal is not restricted to static appearance, as all characters are also evaluated by dynamic components.

The movements are organized into four groups: eye movements, lip movements, body movements, and combined movements. Eye movements include actions such as looking, blinking, and directing attention. Lip movements are related to speech and the synchronization between audio and mouth expression. Body movements involve displacement, gestures and an attempt to get closer to the character. Finally, the combined movements bring together eyes, lips, and body in a more complex sequence, bringing the experience closer to a complete humanoid interaction. This separation dialogues with studies that point to the relevance of visual and movement factors in the perception of virtual characters (JIANG et al., 2022).

3.4 COLLECTING RESPONSES IN THE ENVIRONMENT ITSELF

A relevant point of the project is the collection of responses integrated with the experience. After exposure to the character, the participant answers questionnaires in the environment itself, using alternatives on a Likert scale. This type of scale is widely used to convert subjective perceptions into statistically analyzable numerical data (AGRESTI; FINLAY, 2021; MAROCO, 2021). This strategy reduces operator interference and preserves continuity of experience, especially in immersive devices. Instead of interrupting the use of HMD to respond on paper or other equipment, the assessment interface is presented in the same interaction flow.

Integrated collection is important because the perception of presence and naturalness can be sensitive to interruptions. Removing the participant from the environment or introducing the researcher's mediation between one scene and another could alter the experience, creating methodological noise. Thus, the response within the environment itself contributes to keeping the participant's attention on the stimuli evaluated.

4 EVALUATION METHODOLOGY

4.1 RESEARCH DESIGN

The investigation adopts a quantitative approach, appropriate to the analysis of subjective responses converted into numerical measures by means of scales (AGRESTI; FINLAY, 2021; MAROCO, 2021). The type of display device is the main independent variable. The dependent variables are the perceptions attributed by the participants to the characters and the experience, including human likeness, strangeness, sympathy, presence and naturalness of the movements.

The comparison between visualization groups was performed by one-factor analysis of variance, followed by Tukey's post-hoc tests when significant differences were identified. This strategy allows us to verify whether the means of the responses differ between the devices and, when they differ, to indicate in which pairs of devices the differences are concentrated (MONTGOMERY, 2013; RABE-HESKETH; EVERITT, 2007).

Table 2 shows the organization of the variables considered in the evaluation, distinguishing the independent variable from the dependent variables analyzed in the study.

Table 2

Variables analyzed in the study

Category	Variable	Synthetic Description
Independent variable	Display Type	Monitor, HMD-RV and HMD-RA

Category	Variable	Synthetic Description
Character perception	Similarity	Degree to which the character is perceived as human-like
Character perception	Strangeness	Degree of perceived discomfort or estrangement
Character perception	Sympathy	Degree of acceptance or positive evaluation of the character
Experience	Presence	Feeling of being in the environment presented
Movements	Naturalness of the eye	Perception of the naturalness of the eyes and blinks
Movements	Lip naturalness	Perception of the naturalness of speech and lips
Movements	Body naturalness	Perception of the naturalness of gestures and displacements
Movements	Combined naturalness	Perception of eye, lip and body movements together

Source: prepared by the authors.

Table 2 shows that the independent variable corresponds to the type of display used, including the three viewing conditions: Monitor, HMD-RV and HMD-RA. The other variables represent perceptual dimensions attributed by the participants to the characters and the viewing experience. Among them are human likeness, strangeness and sympathy, directly related to the perception of the 3D humanoid character. Presence is also included, associated with the feeling of insertion in the environment presented. Finally, the variables related to the naturalness of the movements are considered, divided into eye, lip, body and combined movements.

This organization allows structuring the analysis in a systematic way, relating each visualization condition to the participants' perceptive responses to the evaluated characters.

4.2 PARTICIPANTS

The sample size calculation was guided by the G*Power software (FAUL et al., 2009), considering a significance level of 0.05 and statistical power of 0.71. This calculation indicated the minimum need of 129 participants to detect significant differences between the experimental groups.

The definition of statistical power considered practical limitations related to the availability of HMD devices, the average execution time of each session, and the battery life of the equipment used. The use of G*Power as a sample planning tool follows its application in statistical power analyses for experimental designs (FAUL et al., 2009).

The inclusion criteria included adult participants, aged between 18 and 65 years, without distinction of sex and with completed high school. Exclusion criteria were the presence of severe visual or hearing impairments and conditions that could generate discomfort or risk during the experience, such as epilepsy. The adoption of these criteria sought to preserve the safety of the

participants and reduce perceptual interference that could compromise the evaluation of the stimuli.

4.3 EXPERIMENTAL PROCEDURE

The experimental procedure was organized in successive stages. Initially, the test environment was prepared and, in the case of HMDs, the safe limits of space use were defined. In the case of AR, additional calibration was performed to determine the reference point for the presentation of the characters in the physical environment. After this preparation, the participant took a brief training to familiarize themselves with the interface and controls.

After the training, the participant began to visualize the characters according to the experimental condition. The characters were presented in random order, defined by the application, with alternation between static and moving situations, according to the experiment analyzed. After each exposure, the participant answered the corresponding questionnaire. In the end, the data were stored for later statistical processing.

4.4 INSTRUMENTS AND STATISTICAL ANALYSIS

The answers were collected by questionnaires with Likert-type scales, allowing the transformation of subjective perceptions into numerical data. This type of instrument is suitable for measuring degrees of agreement, perceptual intensity, or subjective evaluation, as long as the results are interpreted in a manner compatible with the study design (AGRESTI; FINLAY, 2021; MAROCO, 2021).

Statistical analyses were conducted using scripts developed to extract data from the database generated by the application, organize responses by device and variable, perform one-factor ANOVA, apply Tukey's post-hoc tests, and generate graphical representations, such as boxplots, means with confidence intervals, and scatter and regression plots. The analytical set allowed us to examine both global differences between devices and specific patterns associated with each perceptual variable, following appropriate statistical procedures for comparing means between groups (MONTGOMERY, 2013; RABE-HESKETH; EVERITT, 2007).

5 RESULTS AND DISCUSSION

5.1 FACIAL MOVEMENTS AS AN AXIS OF PERCEPTUAL ANALYSIS

The analysis of the results focuses on the influence of the facial movements of the 3D humanoid characters on the perception of the Valley of Strangeness in augmented reality and

virtual reality environments. Although the study contemplates different perceptual dimensions, the approach adopted here favors eye and lip movements, as they constitute sensitive elements in the social reading of humanoid characters. The gaze, the blinks, the direction of attention and the synchronization of speech with mouth movements are components that directly interfere with the perception of naturalness, and can reduce or intensify the discomfort associated with the Valley of Strangeness.

This choice is justified because the human face plays a central role in non-verbal communication and in the evaluation of humanoid entities. Small inconsistencies in eye or lip movements tend to be easily perceived by the observer, especially when the character has an appearance close to that of a human. In this sense, the classic hypothesis of the Valley of Strangeness indicates that the emotional reaction to artificial entities does not depend only on the degree of human resemblance, but also on the coherence between appearance and perceived behavior (MORI; MACDORMAN; KAGEKI, 2012).

In immersive environments, in which the user perceives the character on a spatial scale and with greater proximity, the naturalness of facial movements becomes a decisive factor for perceptual acceptance. Thus, the results obtained allow us to discuss how augmented reality and virtual reality displays modulate the way these movements are perceived and how this perception is related to the intensification or attenuation of strangeness.

5.2 NATURALNESS OF EYE MOVEMENTS IN AR AND VR

Eye movements are one of the most relevant elements in the perception of humanoid characters, as they indicate attention, communicative intention and social presence. Eyes that do not properly follow the user's position, overly mechanical blinks, or the absence of coherent eye contact can generate a sense of artificiality. In near-human characters, this artificiality tends to be associated with the Valley of Strangeness, since the user recognizes human traits, but notices subtle flaws in their behavior.

In the results regarding the naturalness of eye movements, it is observed that immersive devices have a favorable performance compared to conventional visualization. Statistical analysis identified a significant effect of the type of device on the perception of eye movements, indicating that the form of visualization interferes in the participants' evaluation. The results of the post-hoc test point to differences between the monitor and the immersive devices, while the difference between HMD-RA and HMD-VR is not significant in one of the analyses, suggesting that both immersive environments favor the perception of eye movements over non-immersive visualization.

This result indicates that immersion can function as a perceptual support element for eye movements. In HMD-VR, the character is perceived within a controlled virtual environment, in which lighting, scale, and distance can be standardized. In HMD-RA, the character appears superimposed on the physical environment, establishing a direct spatial relationship with the participant. In both cases, the user ceases to observe the character as a figure restricted to a screen and begins to perceive him as an entity positioned in a three-dimensional space. This alteration in the spatial relationship may contribute to greater perceptual tolerance to facial movements and to less intensification of strangeness.

The literature on virtual characters indicates that eyes and body features are relevant factors in the evaluation of CG-generated characters, especially when there is an expectation of human realism (JIANG et al., 2022). Thus, the evaluation of eye movements in AR and VR reinforces the need to treat the gaze as an expressive component and not only as a technical detail of animation.

5.3 NATURALNESS OF LIP MOVEMENTS AND SYNCHRONIZATION WITH SPEECH

Lip movements present another critical dimension for the perception of naturalness. When a character speaks, coherence between audio, mouth opening, syllable rhythm and facial expression is expected. If this synchronization is perceived as artificial, the user tends to identify a rupture between human appearance and animated behavior. This rupture is especially important in the context of the Valley of Strangeness, as realistic humanoid characters create greater expectation of correspondence between speech and expression.

The analysis of lip movements indicates statistically significant differences between the devices tested. The results show that the perceived naturalness of lip movements was greater in the HMD-RA compared to the monitor and the HMD-RV, while the difference between HMD-VR and monitor was not significant in one of the analyses reported. This finding suggests that AR may favor the reading of facial movements, especially when the character is perceived as inserted in the participant's physical space.

One possible interpretation is that the augmented environment offers a particular combination of spatial presence and reference to the real world. The virtual character, when viewed in the same physical environment as the user, can be perceived as more integrated into the interaction situation, which favors the acceptance of their lip movements. In HMD-VR, although there is immersion, the entire environment is virtual, which can make speech perception more dependent on the overall coherence of the scene, rendering, and character expressiveness. Thus, AR seems to offer a specific advantage in the perception of lip

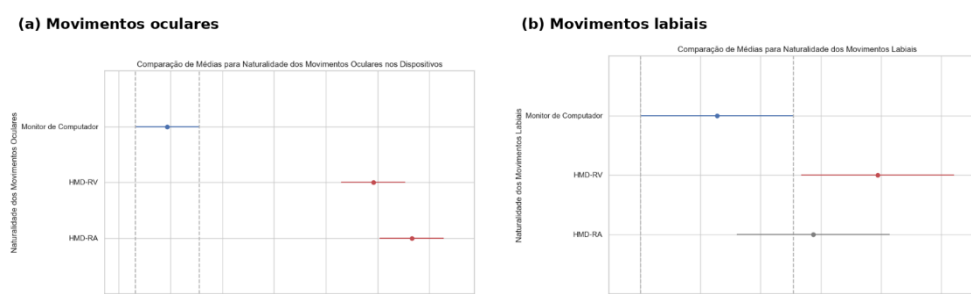
movements, functioning as a bridge between the virtual character and the physical context of the observer.

This discussion is consistent with studies that indicate that direct interaction and perception of a virtual body or character can influence the experience of presence and the illusion of body interaction in immersive environments (LUGRIN; LATT; LATOSCHIK, 2015). In the case of lip movements, this relationship becomes even more sensitive, as speech presupposes a direct communicative bond between character and participant.

Figure 3 presents, in a comparative way, the means of perceived naturalness of facial movements in the three devices evaluated. The composition gathers the results related to eye and lip movements, allowing us to observe differences between the non-immersive condition, represented by the computer monitor, and the immersive conditions, represented by the HMD-VR and the HMD-RA.

Figure 3

Comparison of the perceived naturalness of facial movements between the devices



Source: prepared by the authors.

Figure 3 shows that the perceived naturalness of eye movements presents higher values in immersive devices compared to computer monitors. HMD-RA has the highest average in this dimension, followed by HMD-RV, while the monitor concentrates the lowest average. This behavior suggests that visualization in immersive environments can favor the perception of gaze movements, possibly by inserting the character in a closer and more coherent spatial relationship with the participant.

Regarding lip movements, Figure 3 indicates the highest mean for HMD-RV, followed by HMD-RA and computer monitor. Although confidence intervals should be considered in interpretation, the visual set reinforces that facial movements are perceived differently according to the type of display used.

In this way, the image complements the discussion by showing that facial naturalness does not depend only on the character's animation, but also on the technological context in which this animation is presented.

5.4 INFLUENCE OF FACIAL MOVEMENTS ON THE PERCEPTION OF THE VALLEY OF STRANGENESS

The results reinforce that the Valley of Strangeness does not depend only on the degree of visual realism of the character, but also on the dynamic coherence of his movements. A humanoid character can have an acceptable visual appearance and still generate discomfort if their eyes or lips move artificially. Conversely, facial movements perceived as natural can reduce the sense of awkwardness, even when the character does not achieve full human realism.

In AR and VR environments, this relationship becomes even more sensitive. Spatial proximity and the sense of presence expand the perception of facial details. The user doesn't just observe the character; it shares with it a virtual or augmented environment. In this context, facial movements cease to be a technical detail of animation and become a fundamental part of the perceptual experience.

The comparison between AR and VR suggests that both environments offer relevant conditions for the presentation of humanoid characters, but with distinct perceptual effects. VR favors total control of the scene, allowing you to standardize lighting, background, distance, and framing. AR, in turn, inserts the character into the user's physical space, producing a hybrid experience in which the virtual is perceived in relation to the real. In the case of facial movements, this integration can favor perceived naturalness, especially in lip movements, as the character seems to occupy the same communicative space as the participant.

With this, the perception of the Valley of Strangeness comes to be understood as the result of a combination of appearance, movement and visualization technology. The display does not only act as a neutral means of display, but as an element that participates in the perceptual construction of the character. This finding is especially important for augmented and virtual reality projects, in which the proximity between user and character tends to amplify the perception of facial details.

5.5 IMPLICATIONS FOR HUMANOID CHARACTER DESIGN IN AR AND VR

The findings indicate that the development of humanoid characters for immersive environments should prioritize the quality of facial movements from the early stages of

modeling, *rigging*, and animation. Eyes and mouth should not be treated as accessory elements, but as central components of perceptual acceptance.

In AR and VR applications, the character's face tends to be observed at close scale and with greater spatial engagement, which increases the need for coherent and expressive movements.

In the case of eye movements, attention is recommended to the direction of the gaze, the frequency of blinks, the transitions between points of attention and the coherence with the user's position. In the case of lip movements, it is essential to ensure adequate synchronization between speech, mouth opening, and facial expression. The absence of this coherence can break the immersion and intensify the perceptual discomfort.

The results also suggest that characters intended for AR and VR should be tested directly on end-of-use devices. Monitor-only evaluation may not reveal how the character will be perceived in immersive environments. Scale, distance, face orientation, and gaze behavior can produce different effects when the character is presented in HMD-RA or HMD-VR. In this way, the choice of display is not just a technical decision, but a perceptual variable that participates in the construction of naturalness and acceptance of the character.

Finally, the cut in facial movements shows that the Valley of Strangeness can be mitigated not only by reducing or expanding visual realism, but by fine-tuning facial expressiveness, synchronization and presentation context.

For educational applications, digital games, simulations, and immersive training, this result indicates that the quality of the moving face can be as important as the visual quality of the 3D model.

Table 3 summarizes the main aspects discussed in the section, highlighting how facial movements influence the perception of the Valley of Strangeness in AR and VR environments.

Table 3

Synthesis of the influence of facial movements on the perception of the Valley of Strangeness in AR and VR

Aspect analyzed	HMD-RA	HMD-RV	Implication for the perception of the Valley of Strangeness
Eye movements	It favors the perception of the gaze as part of the participant's physical space, bringing the character closer to the real situation of interaction.	It favors the perception of the gaze in a controlled virtual environment, with stability of distance, scale and lighting.	The naturalness of the gaze, the blinks and the direction of attention can reduce the perceived artificiality in the character.

Lip movements	It has a perceptual advantage by inserting the character in the physical environment, making speech more integrated into the communicative situation.	It relies heavily on the coherence between speech, facial animation, and the overall composition of the virtual environment.	The synchronization between speech and mouth movement is decisive to avoid perceptual ruptures associated with strangeness.
Facial coherence	The integration between eyes, mouth, and spatial presence can favor greater acceptance of the humanoid character.	Facial coherence benefits from full control of the virtual set, but requires greater consistency across all elements of the scene.	The face should be treated as an integrated expressive system, and not as an isolated sum of animations.
Spatial relationship with the user	The character is perceived as superimposed on the real environment, which can increase the sense of coexistence.	The character is perceived within a totally virtual environment, which can expand the presence and control of the experience.	The type of display changes the way the user interprets facial movements and their naturalness.
Implication for design	It requires attention to spatial registration, scale, direction of gaze, and integration with the physical environment.	It requires attention to lighting, distance, framing, facial expressiveness and coherence of the virtual scene.	Characters for AR and VR must be tested on the final device, as the monitor evaluation does not reproduce immersive perception.

Source: prepared by the authors.

In Table 3 it is observed that the eye and lip movements do not act only as technical details of the animation, but as central elements for the perceptual acceptance of the 3D humanoid characters. In HMD-RA, the superimposition of the character on the physical environment tends to favor the feeling of coexistence and can make facial movements more integrated into the communicative situation. In HMD-VR, full control of the virtual environment contributes to the standardization of the experience, but requires coherence between face, speech, lighting, scale, and context of the scene.

Thus, Table 3 reinforces that the influence of facial movements on the Valley of Strangeness depends on the articulation between animation and display. The gaze, the blinks, the movement of the lips and the synchronization with speech need to be evaluated in the environment of use itself, as AR and VR produce different forms of presence and spatial relationship with the character. Facial naturalness should be considered a structural dimension in the development of humanoid characters for immersive media, especially when seeking to reduce perceptual discomfort and expand user acceptance.

6 IMPLICATIONS FOR CHARACTER DEVELOPMENT IN IMMERSIVE MEDIA

The results point to practical implications for the development of 3D humanoid characters. The first is that visual realism alone does not guarantee acceptance. In humanoid characters, the closer the person to human appearance, the greater the expectation of coherent

human behavior. Thus, eyes, mouth, and body need to act as an expressive whole. When these dimensions do not align, the user perceives flaws and strangeness can increase, as discussed in studies on visual factors, movement, and perception of the Valley of Strangeness (KÄTSYRI et al., 2015; JIANG et al., 2022).

The second implication is that the display should guide design decisions. A character developed for a monitor will not necessarily be perceived in the same way in HMD-VR or HMD-RA. The scale, distance, direction of gaze, and type of movement need to be tested on the end-of-use device. Comparative studies on avatars and digital characters in monitors, VR, and AR indicate that the display device interferes with the perception of realism, strangeness, affinity, and preference (HEPPERLE et al., 2022; SEYMOUR et al., 2021; YAN, 2019). In AR, spatial registration, lighting, coherence with real objects, and the character's position in the environment must be considered. In VR, one must consider the cohesion of the virtual world and the impact of the character's proximity to the user.

The third implication refers to data collection in immersive environments. The evaluation of characters in AR and VR should not depend only on instruments external to the experience, as interruption can alter perception. Internal questionnaire interfaces contribute to preserving immersion and producing data that is more consistent with the participant's experience.

The findings of this article suggest that immersive devices can be used not only as a means of exhibition, but as elements capable of modulating the perception of the character. Immersion can attenuate strangeness and expand sympathy, presence and naturalness in different conditions. This finding is relevant for projects in education, training, health, entertainment, and digital communication, in which humanoid characters are used to guide, represent, teach, or interact with users.

7 FINAL CONSIDERATIONS

This paper presented the development of AR and VR environments for assessing the perception of the Valley of Strangeness in 3D humanoid characters with facial and body movements. The investigation compared three viewing conditions, computer monitor, HMD-VR and HMD-RA, and analyzed variables related to human resemblance, strangeness, friendliness, presence and naturalness of movements.

The results indicate that the type of display significantly influences the perception of the characters. The computer monitor tends to accentuate the awkwardness in different conditions, while immersive devices, in this case AR and VR HMDs, tend to favor more positive perceptions. HMD-RA shows favorable performance in dimensions related to similarity and friendliness,

while HMD-RV presents advantages in measures of presence and naturalness in certain analyses. Thus, the choice of display is not neutral; She participates in the perceptual construction of the character.

It is also observed that facial and body movements play a central role in the perception of the Valley of Strangeness. Evaluation of humanoid characters should not be limited to static appearance, as dynamic behavior can modify user acceptance. Eye, lip, body, and combined movements need to be planned and tested as a constitutive part of the character design.

As a contribution, the study articulates the development of immersive environments, construction of humanoid characters and quantitative evaluation of perception. The findings offer subsidies for the development of virtual characters in digital games, simulations, training, education, augmented reality experiences and virtual reality applications. For future work, it is recommended to expand the diversity of characters, include physiological measures, and explore real-time interactions with responsive speech, autonomous behavior, and artificial intelligence, following possibilities already discussed in studies with AR, VR, and multimodal evaluation of the Valley of Strangeness (YAN, 2019; SEYMOUR et al., 2021).

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STAINING TECHNIQUES IN COLPOCYTOLOGY IN COWS AND FEMALE DOGS: QUALITY OF CELLULAR VISUALIZATION AND REPRODUCTIVE MONITORING

TÉCNICAS DE COLORAÇÃO NA COLPOCITOLOGIA EM VACAS E CADELAS: QUALIDADE DA VISUALIZAÇÃO CELULAR E MONITORAMENTO REPRODUTIVO

TÉCNICAS DE COLORACIÓN EN LA COLPOCITOLOGÍA EN VACAS Y PERRAS: CALIDAD DE LA VISUALIZACIÓN CELULAR Y MONITOREO REPRODUCTIVO



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ABSTRACT

Vaginal colposcopy constitutes a rapid, accessible, and highly valuable diagnostic method for monitoring the estrous cycle and evaluating the gynecological status of domestic females, being essential for the success of reproductive biotechnologies. Successful reproductive management depends on understanding the morphological changes in the vaginal epithelium in response to hormonal fluctuations, which enables the identification of cellular patterns characteristic of each phase of the cycle. This study addresses the reproductive physiology of bovine and canine females, emphasizing that diagnostic accuracy intrinsically depends on rigor in laboratory processing and the pre-analytical stage. Different staining techniques are discussed, such as Panoptic Rapid, Giemsa, Methylene Green-Giemsa (MGG), Papanicolaou, and Bengal Rose, highlighting that each protocol presents particularities, advantages, and limitations regarding sensitivity and the detailing of cellular structures. The choice of the most appropriate method, as well as the fixative, should be based on the purpose of the examination and the need for clarity in differentiating cell types and detecting pathologies. The standardization of these techniques contributes to professional training and

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to more accurate diagnoses, directly impacting clinical decision-making and the efficiency of assisted reproduction programs.

Keywords: Vaginal Cytology. Estrous Cycle. Stains. Cows. Female Dogs.

RESUMO

A colpocitologia vaginal constitui um método diagnóstico rápido, acessível e de extrema valia no monitoramento do ciclo estral e na avaliação ginecológica de fêmeas domésticas, sendo essencial para o sucesso de biotecnologias reprodutivas. O êxito do manejo depende da compreensão das alterações morfológicas do epitélio vaginal em resposta às flutuações hormonais, o que viabiliza a identificação dos padrões celulares característicos de cada fase do ciclo. Este estudo aborda a fisiologia reprodutiva de fêmeas bovinas e caninas, enfatizando que a precisão diagnóstica depende intrinsecamente do rigor no processamento laboratorial e da etapa pré-analítica. Diferentes técnicas de coloração são discutidas, como Panótico Rápido, Giemsa, Methylene Green-Giemsa (MGG), Papanicolaou e Rosa Bengala, destacando-se que cada protocolo apresenta particularidades, vantagens e limitações quanto à sensibilidade e ao detalhamento das estruturas celulares. A escolha do método mais adequado, bem como do fixador, deve basear-se na finalidade do exame e na necessidade de nitidez para a diferenciação entre os tipos celulares e detecção de patologias. A padronização dessas técnicas contribui para a capacitação profissional e para diagnósticos mais acurados, impactando diretamente na tomada de decisões clínicas e na eficiência dos programas de reprodução assistida.

Palavras-chave: Citologia Vaginal. Ciclo Estral. Corantes. Vacas. Cadelas.

RESUMEN

La colpocitología vaginal constituye un método diagnóstico rápido, accesible y de gran valor en el monitoreo del ciclo estral y en la evaluación ginecológica de hembras domésticas, siendo esencial para el éxito de las biotecnologías reproductivas. El éxito del manejo reproductivo depende de la comprensión de las alteraciones morfológicas del epitelio vaginal en respuesta a las fluctuaciones hormonales, lo que permite identificar los patrones celulares característicos de cada fase del ciclo. Este estudio aborda la fisiología reproductiva de hembras bovinas y caninas, enfatizando que la precisión diagnóstica depende intrínsecamente del rigor en el procesamiento de laboratorio y de la etapa preanalítica. Se discuten diferentes técnicas de coloración, como Panótico Rápido, Giemsa, Verde de Metileno-Giemsa (MGG), Papanicolaou y Rosa de Bengala, destacándose que cada protocolo presenta particularidades, ventajas y limitaciones en cuanto a la sensibilidad y al detalle de las estructuras celulares. La elección del método más adecuado, así como del fijador, debe basarse en la finalidad del examen y en la necesidad de nitidez para la diferenciación entre tipos celulares y la detección de patologías. La estandarización de estas técnicas contribuye a la capacitación profesional y a diagnósticos más precisos, impactando directamente en la toma de decisiones clínicas y en la eficiencia de los programas de reproducción asistida.

Palabras clave: Citología Vaginal. Ciclo Estral. Colorantes. Vacas. Perras.

1 INTRODUCTION

Pap smear, or vaginal cytology, is a non-invasive, rapid, and low-cost diagnostic tool, widely established in veterinary medicine for reproductive monitoring (Cobucci *et al.*, 2024; Costa *et al.*, 2025; Salmazzo; Ferrari, 2019). Through the morphological analysis of exfoliated mucosal cells, the technique helps to identify the phases of the estrous cycle and to detect any pathological changes, being a fundamental test for directing biotechnologies such as artificial insemination and embryo transfer (Brito *et al.*, 2024; Leite *et al.*, 2026; Nogueira *et al.*, 2019; Rodrigues; Bertolini, 2019).

The control of the estrous cycle offers several advantages for the reproductive management of females. This monitoring can be done by different means. In animals that have normal cyclicity, some type of intervention can be dispensed with, however, in some circumstances, it may be desired to induce or suppress estrus, as well as in females that have irregular cycles, interventions can be made to modify this course (Cogo, 2025; Holzlsauer *et al.*, 2025; Silva, 2016; Cobucci, 2024).

In addition, the concentration of estrus and ovulations makes it possible to use other reproductive biotechniques, such as fixed-time artificial insemination (TAI) and fixed-time embryo transfer (TAI). The use of these techniques in conjunction with the control of the estrous cycle allows for a more efficient diffusion of genetics of interest (Oliveira *et al.*, 2023; Teodoro *et al.*, 2023).

The dog's estrous cycle is comprised of the interval between the period of follicular development followed by ovulation, being regulated by endocrine and neuroendocrine mechanisms, and is divided into different and successive phases, namely: proestrus, estrus, diestrus and anestrus. (Cogo, 2025; Holzlsauer *et al.*, 2025; Cobucci *et al.* 2024; Teodoro *et al.*, 2023).

The estrous cycle is a period comprised of two estros, of variable duration, however, it lasts approximately 21 days. In the cow, the phases of the estrous cycle are well defined and divided into proestrus, estrus, metaestrus and diestrus. The investigation pointed out that when comparing cytology tests in cows submitted to Fixed Time Artificial Insemination (TAI) protocols and those with a physiological estrous cycle, without a FTAI protocol, they observed that the cellular patterns were very similar (Nogueira *et al.*, 2019).

The biological basis of the test lies in the response of the vaginal epithelium to fluctuations in sex steroid hormones. Under the influence of estrogen, the epithelium undergoes intense proliferation and undergoes a process of keratinization (cornification), with distinct particularities between species (Silva, 2021). In female dogs, this process is marked during

proestrus and estrus, aiming to protect the mucosa against mechanical friction during copulation (Silva; Lima, 2018). On the other hand, in bovine females, the cellular changes are more subtle and focused on the secretory function; the stratified squamous epithelium does not reach the same degree of keratinization observed in the canine species, which requires greater technical rigor in cell differentiation (Nutricorp, 2022; Rezende, 2006; Silva, 2018).

Microscopic evaluation allows the classification of cells into parabasal, intermediate, superficial, nucleated and anucleated and metaestrus cells, and superficial, as well as the presence of leukocytes, erythrocytes and secretions (Borges *et al.*, 2024; Teodoro *et al.*, 2023). The accuracy of the cytological diagnosis is intrinsically dependent on the pre-analytical laboratory phase. In order for these cellular patterns to be clearly visualized, sample processing, from collection via sterile *swab* to fixation, is a critical step. Immediate cell fixation is essential for the preservation of structural proteins and the interruption of autolytic processes, avoiding cell lysis and the formation of artifacts that make reading unfeasible (Paiva *et al.*, 2024; Santos *et al.*, 2022).

Parabasal cells tend to have a rounded shape, and their nucleus/cytoplasm ratio is high, in relation to size it tends to be smaller when compared to other cells in the smear. Intermediate cells have a rounded nucleus, but their size when compared to parabasal cells is relatively larger, and may or may not have a rounded morphology. The superficial cells between the three are considered the largest, where their edges are angular and may contain the presence or absence of a nucleus, when there is the presence of a nucleus, they are considered as a pycnotic nucleus (Borges *et al.*, 2024; Brito *et al.*, 2024).

In this context, the choice of staining protocol plays a decisive role in image quality. The efficiency of a dye is linked to its electrostatic affinity: cationic (basic) dyes have an affinity for nucleic acids (negative charge), while anionic dyes (acids), such as Rose Bengal, tend to fail nuclear evidence if used alone due to electrostatic repulsion (Benchchem, 2026). Thus, the use of methods such as the Panopticon Rapid, Giemsa, *Methylene Green-Giemsa* (MGG) and Pap smear seeks to optimize the visualization of the structures, balancing the practicality of the routine with the morphological detail necessary for the diagnosis (Teodoro *et al.*, 2023; Paiva *et al.*, 2024).

In addition to the choice of reagents, the physical management of the sample impacts the feasibility of the diagnosis. Sterile *swab* collection and fine-rolling smears are essential for the formation of a cell monolayer, avoiding the overlap that prevents analysis (Paiva *et al.*, 2024; Teodoro *et al.*, 2023). In view of the importance of standardizing these methods, this study aims to review the literature on staining techniques in the colpocytology of cows and bitches.

Therefore, vaginal cytology identifies the phase of the estrous cycle due to the morphological alteration that the vaginal epithelial cells undergo during this cycle, helping at the most appropriate time to perform natural mounting or artificial insemination (Leite *et al.*, 2026; Santos *et al.*, 2022; Teodoro *et al.*, 2023).

Thus, the monitoring of the estrous cycle, combined with vaginal cytology, not only

It improves reproductive management practices, but also contributes to their efficiency. A detailed understanding of the phases of the estrous cycle, behavioral and hormonal changes, as well as changes in vaginal cells and the choice of different dyes are key to ensuring reproductive success, allowing for precise and timely interventions that maximize the productivity and genetics of the animals (Nutricorp, 2022; Costa *et al.*, 2025).

It seeks to discuss the theoretical foundations of cytological processing, providing subsidies for the professional to select the most appropriate protocol to ensure accuracy in animal reproductive monitoring (Brito *et al.*, 2024; Costa *et al.*, 2025; Leite *et al.*, 2026; Paiva *et al.*, 2024).

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SEVERE FLOODS AND DROUGHTS, EVANGELICAL EXPANSION, AND LUZ PARA TODOS: CHANGING THE LANDSCAPE AND HABITUS IN RURAL AMAZONAS

CHEIAS E SECAS SEVERAS, EXPANSÃO EVANGÉLICA E LUZ PARA TODOS: MUDANDO O CENÁRIO E O HABITUS NO RURAL DO AMAZONAS

INUNDACIONES Y SEQUÍAS SEVERAS, EXPANSIÓN EVANGÉLICA Y LUZ PARA TODOS: CAMBIANDO EL PAISAJE Y EL HABITUS EN EL ÁMBITO RURAL DEL AMAZONAS



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ABSTRACT

Changes in landscapes are influenced by natural and anthropogenic factors and have occurred for a long time. However, they became more intense after the Industrial Revolution (18th century), promoting major rural exodus, and after Globalization (20th century), leading to the urbanization of rural areas. In Amazonas, it was observed that Severe Floods and Droughts – climate change-related events – (SFD), the Expansion of Evangelical Religion (EER), and the implementation of the social program Luz para Todos (LPT) resulted in significant transformations in the landscapes of community centers and localities, as well as in the habitus of traditional and Indigenous peoples. Thus, this study aimed to investigate the impacts of the aforementioned phenomena and factors on the socioeconomic (anthropological/cultural) and physical (landscape) aspects of rural settlements in Amazonas. The study was carried out through visits to traditional communities in the municipalities of Careiro, Careiro da Várzea, Coari, Codajás, Iranduba, Itacoatiara, Itapiranga, Manacapuru, Presidente Figueiredo, Rio Preto da Eva, Silves, and Urucurituba over the last ten years. To this end, literature reviews and in loco observations were conducted using photographic records and field notes. The results demonstrated that all the natural and anthropogenic phenomena and themes studied

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contributed to these changes. Severe Floods and Droughts, together with the Expansion of Evangelical Religion, were the factors that most contributed to alterations in the landscapes of community nuclei and territories. In turn, the Luz para Todos program, associated with improvements in the road network, most strongly favored transformations in the habitus of the inhabitants, especially among older individuals.

Keywords: Climate Change. Rural Landscape. Indigenous Community. Traditional Peoples.

RESUMO

As mudanças nos cenários são influenciadas por fatores naturais e antrópicos e acontecem há muito tempo. Contudo, tornaram-se mais intensas após a Revolução Industrial (séc. XVIII), promovendo grande êxodo rural e depois da Globalização (séc. XX), a urbanização do meio rural. No Amazonas observou-se que com as Cheias e Secas Severas – mudanças climáticas – (CSS), a Expansão da Religião Evangélica (ERE) e a implementação do programa social Luz para Todos (LPT), ocorreram significativas transformações nos cenários das sedes e das localidades e no habitus dos povos tradicionais e indígenas. Assim, este trabalho visou estudar os impactos dos fenômenos e fatores supracitados sobre os aspectos socioeconômicos (antropológicos/culturais) e físicos (cenários) dos povoados rurais do Amazonas. Foi realizado por meio de visitas às comunidades tradicionais dos municípios de Careiro, Careiro da Várzea, Coari, Codajás, Iranduba, Itacoatiara, Itapiranga, Manacapuru, Presidente Figueiredo, Rio Preto da Eva, Silves e Urucurituba, nos últimos 10 anos. Dessa forma, fez-se uso de revisões de literatura e observações in loco recorrendo à registros fotográficos e anotações. Os resultados demonstraram que todos os fenômenos naturais ou antrópicos e as temáticas estudadas contribuíram para as alterações. Sendo as CSS e a ERE as que mais colaboraram para as alterações nas paisagens dos núcleos e dos territórios comunitários. Por sua vez, o LPT associado às melhorias da malha viária, foram os que mais favoreceram as transformações no habitus das pessoas, sobretudo dos mais velhos.

Palavras-chave: Mudanças Climáticas. Paisagem Rural. Comunidade Indígena. Povos Tradicionais.

RESUMEN

Los cambios en los paisajes están influenciados por factores naturales y antrópicos y ocurren desde hace mucho tiempo. Sin embargo, se intensificaron después de la Revolución Industrial (siglo XVIII), promoviendo un gran éxodo rural, y posteriormente con la Globalización (siglo XX), impulsando la urbanización del medio rural. En el Amazonas, se observó que las Inundaciones y Sequías Severas —relacionadas con el cambio climático— (ISS), la Expansión de la Religión Evangélica (ERE) y la implementación del programa social Luz para Todos (LPT) provocaron importantes transformaciones en los paisajes de las sedes y localidades, así como en el habitus de los pueblos tradicionales e indígenas. Así, este trabajo tuvo como objetivo estudiar los impactos de los fenómenos y factores antes mencionados sobre los aspectos socioeconómicos (antropológicos/culturales) y físicos (paisajes) de las comunidades rurales del Amazonas. El estudio se realizó mediante visitas a comunidades tradicionales de los municipios de Careiro, Careiro da Várzea, Coari, Codajás, Iranduba, Itacoatiara, Itapiranga, Manacapuru, Presidente Figueiredo, Rio Preto da Eva, Silves y Urucurituba durante los últimos diez años. Para ello, se recurrió a revisiones bibliográficas y observaciones in situ mediante registros fotográficos y anotaciones de campo. Los resultados demostraron que todos los fenómenos naturales o antrópicos y las temáticas estudiadas contribuyeron a las transformaciones observadas. Las Inundaciones y Sequías Severas y la Expansión de la Religión Evangélica fueron las que más contribuyeron a las alteraciones en los paisajes de los núcleos y territorios comunitarios. Por su parte, el programa Luz para Todos, asociado a las

mejoras de la red vial, fue el factor que más favoreció las transformaciones en el habitus de las personas, especialmente de los adultos mayores.

Palabras clave: Cambio Climático. Paisaje Rural. Comunidad Indígena. Pueblos Tradicionales.

1 INTRODUCTION

The different scenarios make up the landscape of a place, so the landscape is influenced by natural and anthropic or cultural factors (CONTI, 2014; BERNARDES, 2020; LEPLAN, 2026). Thus, changes in rural environments have been happening for a long time, but they became remarkable after the Scientific Revolution of the seventeenth century (ROQUE, 2002).

The aforementioned revolution substantially increased the domination and expansion of territories, peoples, cultures, and sciences; the consumption of natural resources; it promoted social, political, technological and scientific development (ROQUE, 2002; ROSA, 2012; KUHN, 2013; SEABRA, 2016); it was established with the use of fossil fuels (coal) and boosted industrialization, which was improved by technical and economic research (ABIKO et al., 1995; CARPANEZZI et al., 2017; COSMO et al., 2020).

Furthermore, as a consequence of the Scientific Revolution, the Industrial Revolution (eighteenth century) occurred, which caused gigantic changes in the rural environment, as the migration of people from the countryside to industrialized centers where there was a demand for labor for industrial production - rural exodus - caused negative impacts such as the reduction of labor in the countryside, which culminated in the decrease in food production and the increase of mechanized work in agriculture (ABIKO et al., 1995; CARPANEZZI et al., 2017). These actions contributed to a series of Agricultural Revolutions over time (Modern Agriculture (eighteenth century) – Agriculture 4.0 (twenty-first century) (MAZOYER; ROUDART, 2010; KAMIYAMA, 2011; LEMOS, 2017; MASSRUHÁ; LEITE, 2018; LISBINSKI et al., 2020; CARVALHO; PANATTA, 2021; BESSA, 2022).

Nevertheless, from the 60s onwards, socioeconomic changes occurred in rural environments around the world, where many residents of these environments were not rural producers, that is, their income and savings did not come from agricultural production (FULLER, 1990; BALSADI, 2001).

In the 2000s, it was observed that non-agricultural rural jobs were significant in the rural development process, because in Latin America 50% of jobs in rural areas were non-agricultural, these changes became relevant after the Green Revolution and contributed to rural-urbanization until the emergence of globalization (REARDON; STAMOULIS; PINGALI, 2007).

In Amazonas, interesting and worrying environmental and socioeconomic transformations have been noted that have been changing the scenarios and *habitus in traditional communities* in the last 10 years. The main causes are the severe floods and droughts (CSS) intensified by Climate Change (MC), the Expansion of the Evangelical Religion (ERE) and the implementation of the Federal Government's social program Light for All (LPT).

Therefore, it is necessary to study what are and if they are positive or negative the impacts that these factors and phenomena have promoted in the traditional communities of Amazonas, both in socioeconomic (anthropological/cultural) and physical (scenarios) aspects; their influences on the habits of people living in the forest and whether these transformations have provided an improvement in the quality of life of traditional and indigenous peoples. Therefore, the present study aimed to evaluate the impacts of SSC, the expansion of the evangelical religion and the social program light for all on the scenario and *habitus* in rural Amazonas.

2 METHODOLOGICAL PROCEDURES

The studies were developed in the State of Amazonas over a period of 10 years through observations on the changes in the scenarios and *habitus* of the residents of traditional communities inserted in the patterns of occupation in the river-man-floodplain-terra firme and in the terra firme-man-highway interfaces in the municipalities of Careiro, Careiro da Várzea, Coari, Codajás, Iranduba, Itacoatiara, Itapiranga, Manacapuru, Presidente Figueiredo, Rio Preto da Eva, Silves and Urucurituba, and the causes that promoted them. A literature review was carried out for each theme addressed and notebooks and cameras were used in the field. The trips were made by canoes, speedboats, boats and vehicles. There were some particularities in some topics studied, about:

2.1 TRADITIONAL COMMUNITIES

The observations and records (photographic and written) were made in the communities during the numerous excursions in the 12 municipalities visited.

2.2 SEVERE FLOODS AND DROUGHTS (CLIMATE CHANGE)

Observations of the impacts of major floods and droughts were recorded in Coari, Itapiranga and Silves and on the banks of the Solimões River in the municipalities of Coari, Codajás, Iranduba and Manacapuru.

2.3 EXPANSION OF THE EVANGELICAL RELIGION

Observations on the changes in the scenarios of traditional communities were recorded in the 12 municipalities visited.

2.4 LIGHT FOR ALL SOCIAL PROGRAM

The notes of the information acquired and the records on the contribution to the changes in the scenarios of traditional communities were recorded in the 12 municipalities visited.

2.5 THE NEW SCENARIO AND THE CHANGE OF *HABITUS* IN TRADITIONAL COMMUNITIES

To elucidate these changes, the data obtained on each theme addressed was organized and this information was analyzed together, the results were discussed and a new structure of the communities was elaborated that allows the description/visualization of the changes in the scenarios and *habitus*.

3 ANALYSIS AND DISCUSSION OF THE RESULTS

3.1 TRADITIONAL PEOPLES AND COMMUNITIES

The history of the Amazon region is famous for the exploitation and appropriation of its natural resources under foreign demands and its foreign exchange. However, traditional peoples, especially the riverside dwellers, gained from the indigenous people the techniques on environmental management, agricultural production and social organization (FERNANDES; MOSER, 2021).

Studies on traditional peoples are vast and, depending on the point of view, the same man can be seen as a riverside dweller, a varjeiro, a fisherman, an extractivist, a quilombola and a rubber tapper, since the definition of his denomination depends on his activities and the place where he lives (LIRA; CHAVES, 2016).

The riverside dwellers stand out among the traditional peoples in the Amazon, since they live on the banks of numerous rivers of gigantic extensions, a situation that allows them greater and better advantages for the enjoyment of natural resources, especially with the practices of fishing, hunting, extractivism and agriculture (especially through the use of floodplains), as well as facilitating access to transportation that, in the absolute majority of times it is exclusively fluvial (FRAXE, 2000; FERNANDES; MOSER, 2021).

There are many definitions/concepts about the riverside dwellers, and the common point among the works is the description of the place they inhabit, their socioeconomic and cultural particularities and their high relationships with nature.

Then, in the face of a vast literature (among them, ARENZ, 2000; FRAXE, 2004; FRAXE; WITKOSKI; MIGUEZ, 2009; PEREIRA; DIEGUES, 2010; RENTE NETO; FURTADO, 2015; LIRA; CHAVES, 2016; CHAVES; FURTADO, 2017; OLIVEIRA; SAUER, 2021; CAÑETE, 2023;

MMA, 2024), the riverside dwellers can be characterized as: social groups, composed of mestizo people, coming from miscegeny, mainly among blacks (quilombolas), northeasterners and Indians, commonly called caboclos, with peculiar forms of social, cultural, religious, ancestral and economic organizations, which over time and, especially, economic cycles, have spread and inhabited the banks of the countless and mighty rivers, essentially, from the Amazon, maintaining a vital, healthy and sustainable relationship with the environment, holding great wisdom about this link, which is spread from generation to generation. In addition, they practice small crops and livestock, artisanal fishing, hunting and extractivism (mineral, vegetable and animal) as their fundamental activities and maintain social, economic and cultural relations with population centers.

Most of the riverside dwellers live in the floodplains and often act simultaneously as fishermen, hunters, extractivists and rubber tappers; are formed and form a mixed population, obeying a pattern of occupation at the river-man-floodplain-terra firme interfaces (CRUZ, 2023).

From the banks of the Amazonian rivers where the riverside dwellers live, for whom the river is symbolic and representative, riverside territoriality is established. Therefore, obviously, the lives of these social actors are enormously influenced by the rainfall regime of the waters, determining the construction of houses, the time and time for the practices of hunting, fishing and plant extractivism, among other things (FERNANDES; MOSER, 2021).

Contemporaneously, due to the remarkable interaction of the peoples who live in the Amazon with the environment, singularly with its natural resources of fauna and flora, studies in this desired region have considered the traditional peoples (formed mainly by riverside dwellers, varjeiros/varzeiros, fishermen, extractivists, rubber tappers and quilombolas) and original (indigenous) (LIRA; CHAVES, 2016).

When the social groups formed by traditional peoples are grouped in a certain place, they form rural communities that are characterized by presenting, almost always, a structured social organization with a **church, social center, school, flour house and soccer field**, these collective spaces forming the community headquarters (MIGUEZ; FRAXE; WITKOSKI, 2011).

Rural communities, also called riverine or traditional communities, can be recognized as:

“[...] a territorial locus in which a singular model of natural resource management and social organization is instituted, where individuals build their social identity by safeguarding a set of knowledge that is transmitted from generation to generation, but which is updated in the dynamics of the history of struggles and resistance in the search for the recognition of their sociocultural identities” (CHAVES; RIBEIRO; MELO, 2023, p. 18).

Therefore, shared knowledge – ethnoknowledge – allows them to conduct the sustainable use of natural resources, reducing environmental damage (ARAÚJO, 2023; MMA, 2024). In view of this, the headquarters of the communities where the elders are located, meet the conditions to be seen as **"Universities of Ethnoknowledge about the Amazonian environments and the multiple forms of use and management of its natural resources"**.

3.2 SEVERE FLOODS AND DROUGHTS (CLIMATE CHANGE)

The great floods that occurred in Amazonas have caused harm to the environment (water contamination, soil erosion; air pollution); in human health (waterborne diseases, vector-borne diseases, physical injuries and traumas, psychological stress and emotional trauma, malnutrition and food shortages, population displacement); in vegetation (damage to agricultural crops and destruction of terrestrial vegetation, siltation of green areas); in biodiversity (habitat loss, displacement of fauna, alteration in aquatic ecosystems, expansion of invasive species) (MICHILES et al., 2025).

These disasters have contributed to changing the scenarios and favored migrations and, consequently, the *habitus* of people who live in traditional and indigenous communities. However, this work will focus on the impacts of major droughts for the sake of limited space.

In view of this, the severe droughts that occurred in Amazonas in 2023 and 2024 lead us to believe that they are consequences of CM, since they have caused climate extremes and these engender disturbances of different kinds, including major droughts, floods, extreme heat, water insecurity, and food insecurity (LEVIN; BOEHM and CARTER, 2022). In addition, it promotes an increase in diseases (LEVIN; BOEHM; CARTER, 2022).

Because of this, this category is the most studied among the 9 categories that form planetary boundaries. The Intergovernmental Panel on Climate Change (IPCC), in the synthesis report on climate change in 2023, adduces that global and rapid changes have occurred in the atmosphere, ocean, cryosphere, and biosphere, these signs of transformations were observed in the extreme situations that occurred (tropical cyclones, heat waves, intense rains, and major droughts) (IPCC, 2023).

Thus, the KM have been hindering efforts to achieve the United Nations Sustainable Development Goals (SDGs), mainly due to the compromise of water security, which contributes to the reduction of food security. In addition, 3.3 to 3.6 billion people are under a situation of high vulnerability to climate extremes. It should be noted that human action has been more intense, providing many climatic and meteorological extremes in all regions of the world,

causing adverse and widespread impacts and related loss and damage to nature and people (IPCC, 2023).

In Brazil, the greatest damage is due to major droughts and floods. Causing major negative impacts, mainly in the higher cost of energy supply, in the reduction of food supply, causing shortages, increasing demand and, consequently, the price, and in the increase in the cost of transportation (MIATO; CATTO, 2024). In addition, it contributes to the worsening of the population's health situation (ARTAXO, 2020).

The major droughts of the rivers of the Legal Amazon have directly affected six of the nine states (Acre, Amapá, Amazonas, Pará, Rondônia, and Roraima), among which the state of Amazonas is the most impacted, with about 557 thousand people affected by the lack of drinking water, food, and river transport (G1-AM, 2023). In addition, because it has the second largest national port in terms of cabotage container flow and, due to the lack of navigability of the rivers, the Amazon negatively and significantly impacts the economy of the North region and Brazil, by reducing the Gross Domestic Product (GDP) and increasing unemployment (LIMA, 2023).

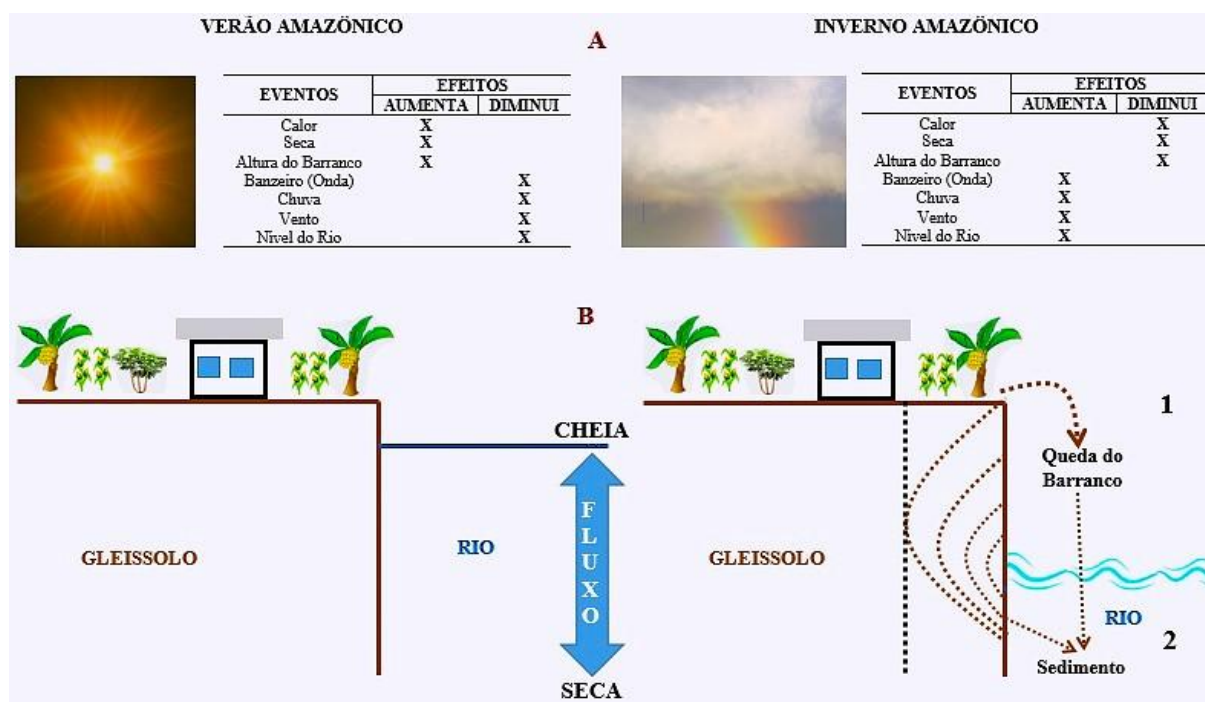
3.2.1 Impacts of Severe Droughts in Amazonas

The different astronomical, atmospheric and geographical factors of each region of planet Earth promote climatic dissimilarities. Thus, in Amazonas it is noticeable only two seasons in the year, Amazonian summer and winter, that is, a dry season and a rainy season. The natural phenomena of floods and droughts in the Amazon in most of the floodplain areas promote the phenomenon of fallen lands (natural geological-geomorphological occurrence of river erosion (landslide) (DANTAS; MAIA, 2010; SILVA, 2022) (Figure 1).

The multifarious and free occurrence of fallen lands involves natural factors (neotectonic, climatic (wind and rain), hydraulic water pressure, hydrostatic pressure in the alluvial area, physical characteristics and vegetation cover of the soil on the banks) and anthropic factors (deforestation of riparian forest and vessels, especially boats, motorboats and ships that produce strong banzeiros) (CARVALHO; CUNHA, 2011).

Figure 1

Events and scenarios in the periods of flood and drought in Amazonas. A - Comparison of events and their effects in periods of floods and droughts. B - Schematic drawing of the dynamics of river water and floodplain soil in the face of flood and drought processes



Legend: 1 and 2 – Phenomenon of fallen lands. 1 – Fall of the ravine, causing loss of part of the production area, reducing food production; 2 – Accumulation of sediments in the riverbed, causing siltation. Source: the author based on the works of Dantas and Maia (2010); Carvalho and Cunha (2011) and Marques (2017).

In Amazonas, major droughts have caused major socioeconomic obstacles such as lack of drinking water; risk of death by burial; difficulty in performing personal hygiene and household chores (cleaning and feeding); isolation of families, lack of food and resources for the survival and subsistence of those affected, mainly due, in many cases, to the total drought of the rivers and their tributaries, making it impossible to fish and transport, which is practically all river; difficulty in loading and unloading people and goods; risk to navigation due to the low levels of the rivers, leading to accidents on the sandbanks, stumps and stones; reduction of land due to landslides, causing the loss of cultivation area and housing and migration of families, traditional and indigenous communities (CARVALHO; CUNHA, 2011; JESUS, 2024; SANTOS; SILVA, 2024).

Migrations have become relevant for riverside dwellers belonging to the occupation pattern at the river-man-floodplain-terra firme interfaces who, fleeing the problems caused by large floods and ebbs (as seen in 2023 and 2024), are composing the occupation pattern at the land-man-highway interfaces, a situation favored by the increase and improvement of the road network with the opening of new roads and branches by the government, favoring access to

health, education, tourism, leisure, and agricultural production (CRUZ, 2023; SEINFRA, 2023; CEMADEN, 2024; MCTI, 2024) (Figure 2).

Figure 2

Occurrence of the phenomenon of fallen lands on the Manaus – Coari route, navigating the Solimões River, this phenomenon worsened after the major droughts that occurred in 2023 and 2024. A and B – Residences in the process of abandonment; C – Abandoned residence



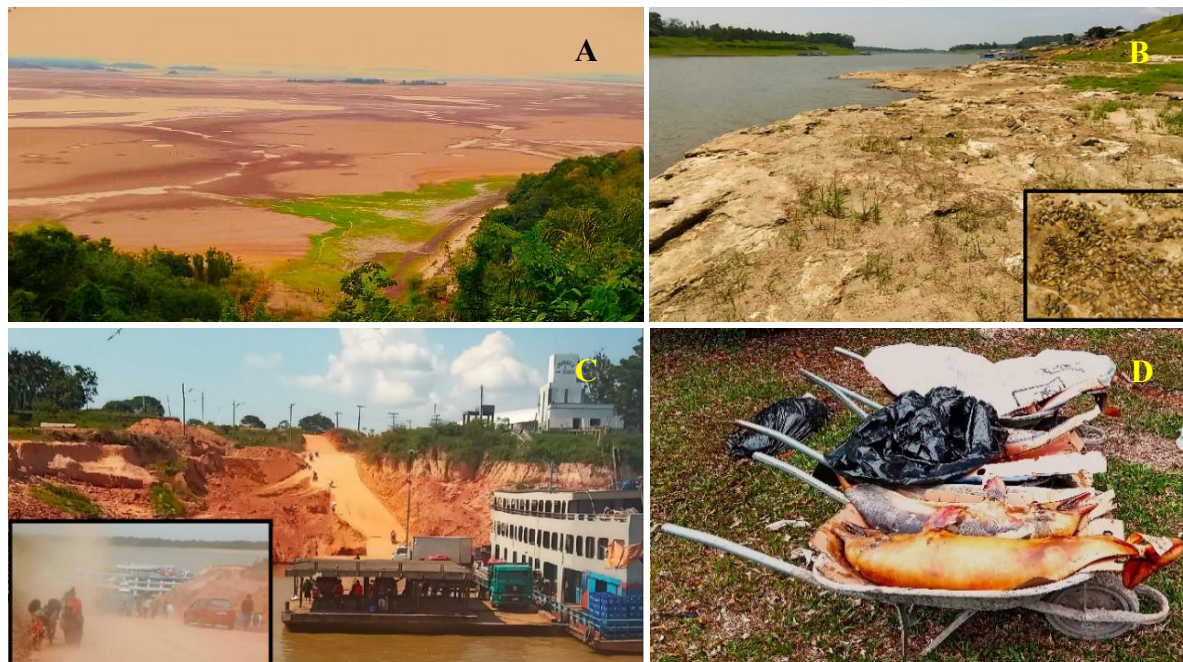
Source: the author.

The negative impacts caused by the landslide occur throughout the Amazon such as in Tefé-AM (Middle Solimões), Itacoatiara-AM (Middle Amazonas); Parintins-AM and Santarém-PA (Lower Amazonas) (CARVALHO; CUNHA, 2011; MARQUES, 2017; VALE et al., 2019; SILVA et al., 2023).

Records from the last decade show that there are still significant gaps in the understanding of the impacts of severe droughts in the Amazon, many of these damages have not been properly identified, described and measured. Among them are: the construction of alternative ports in Coari; the great mortality of dolphins (freshwater cetaceans) in Tefé and Coari; the total drought of lakes in Silves, such as Saracá, affecting riverside communities, the landscape, fishing and tourism; and, in Itapiranga, the outcropping of stone slabs in the Paraná de Itapiranga, causing the death of a vast amount of bivalves (shells) (Figure 3).

Figure 3

Scenarios modified by the severe droughts of 2023 and 2024). A – Total drought of Lake Saracá in Silves; B – Stone slabs in Itapiranga. Highlight: dead bivalves; C – Alternative port in Coari. Highlight: passers-by (local travelers and tourists) taken by dust; D – Dead dolphins kept for studies at Ufam/Coari



Source: the author.

Because, only with many, detailed and punctual studies, could one explain or measure the damage caused by KM in Amazonas, such as those recorded in Figure 3: total drought of Lake Saracá in Silves, how many families were affected? What is the damage to fishermen and the tourism production chain? In Itapiranga, what is the consequence, current or future, if the death of a large number of bivalves (freshwater shells that filter water and serve as food for the ichthyofauna) continues to occur due to the outcropping of stone slabs that, in addition, put river transport at risk? In Coari, what are the costs of the construction of alternative ports? What are the inconveniences caused by improvised ports for users and merchants? It should be noted that what happened with the Small Public Port Facility (IP4) in Coari was observed in other municipalities such as Silves and Itapiranga, and what were the causes of the relevant number of dead dolphins and what can this affect the aquatic environment? These are some of the damages observed, so it is evident that only through epistemological cuts (e.g. interdisciplinary studies and social impact) will the necessary technical subsidies for claims on social rights be achieved.

Teixeira (2024) emphasizes that it is extremely necessary to know the intrinsic characteristics of each location, to diagram the most sensitive areas, to listen to the social actors

who live in it so that there is reasoned argumentation, strength, and reason to plead for public policies that minimize socioeconomic problems, especially in the most isolated communities.

3.3 EXPANSION OF EVANGELICAL RELIGION

The Protestant Reformation (historical term) or Ecclesiastical Revolution (evangelical view) occurred in Germany in the sixteenth century and arrived in Brazil in the same century in 1555 and since then, due to some differences between doctrines, there have always been those who preferred those of the Roman Catholic Church to the detriment of the Evangelical ones and vice versa (MOURA, 1999; FREIRE; RIBEIRO; ZIGMANTA, 2022; SILVA, 2024).

Furthermore, when globalization was established in the world (fifth end of the twentieth century) evangelical religions appropriated the mass media to strengthen themselves and favor the creation of identity beyond nationality and this induces people to seek religions in order to solve their material and spiritual problems, which conjecture their salvation after death, socioeconomic success in life and belonging to a group (SANTOS; BRAZ, 2009).

Cruz (2018) stated that:

"The diffusion of the evangelical faith in Brazil was driven by the rise of the Pentecostal movement. It had wide adherence, especially in the less privileged portions of the population, who identified with its message and found in it encouragement to signify their daily lives. The opening of Pentecostalism to the Gospel movement established bridges between the pre-established historical churches markedly sectarian and the rest of society. Its social reintegration and popularization broke with certain historical stigmas and new practices of evangelization and behavior were born" (CRUZ, 2018, p. 16).

Because of this, in Brazil, in the 2022 IBGE census, there was a reduction of 8.3% in the Catholic Religion, which was 65.0% in 2010 and decreased to 56.7% in 2022, while there was an increase of 5.2% in the Evangelical Religion, which was 21.7% in 2010 and changed to 26.9% in 2022. Among the Brazilian regions, the North region has the highest concentration of evangelicals with 36.8% (IBGE, 2022).

However, Oliveira and Pinto (2017) emphasize that in the Brazilian Amazon, the expansion of the Evangelical Religion practiced by American missionaries presented strategies aimed at the economic, social, political and cultural progress of the local population, based on North American values, in a process of colonization promoting changes in the *Amazonian* habitus. As can be seen below:

"Protestantism stands out in an economic and political scenario, where the missionaries defended a government that was sovereign over the Amazon, that would make the region within the trappings of the "American dream". Thus, Protestantism is the most recent influence that the Amazon is experiencing. It is a Protestantism of conversion, of changing one's life, of proselytism, of the denial of one's own culture. Thus, Protestantism reproduced new messianic practices of evangelization and colonization, thus generating a new social and religious dynamic" (OLIVEIRA; PINTO, 2017, p. 124).

3.3.1 Expansion of the Evangelical Religion in Amazonas

In Amazonas, the 2010 IBGE Census showed that Catholics represented 60% and Evangelicals 30.6% of the ≥10-year-old population. In 2022, these populations increased to 47.4% and 39.4% respectively, that is, the Catholic Religion had a reduction of 12.6 percentage points (p.p.) and the Evangelical Religion an increase of 8.8 p.p. (IBGE 2010, 2022).

One of the great practical differences between the Catholic and Evangelical religions is in preaching, while in the Catholic it is necessary to have a priest (graduated in theology within Catholic schools), in the Evangelical one only needs a religious leader and this, according to Oliveira (2012) only needs charisma and this natural ability to influence people comes from good rhetoric, of the understanding of the Holy Bible, in the regency of the liturgy of services, spiritual gifts, being baptized in water and in the Holy Spirit, converted and responsible.

In this way, the expansion of the Evangelical Doctrine is facilitated. In addition, factors such as the locomobility of religious leaders; construction of tents, temples and churches; and the residences of the leaders in the communities (living daily with the other residents), drive this growth and substantiate territoriality in traditional communities. These are presented as important territories to be occupied by these beliefs, as occurred in the Negro and Solimões rivers, since the Catholic Church does not occupy these spaces (ALVES; PEREIRA; D'ANTONA, 2024).

Oliveira (2012), when conducting studies in the communities of Our Lady of Perpetual Help, Assembly of God, Santa Izabel and Assembly of Traditional God, in Jaiteua de Cima, a locality located on the shores of Lago Grande in Manacapuru-AM, observed that most of the riverside dwellers living in these communities were evangelicals belonging to different churches of the Pentecostal movement (Assembly of God, United Pentecostal of Brazil, Traditional Assembly of God). The author points out that in this study she evidenced the occurrence of the dichotomy union and division promoted by belief, that is, religion united people in a single community (Catholic) but also separated them, giving rise to 3 more communities, of which 2 are formed by evangelicals in their vast majority.

In fact, in the Amazon and Amazonas, as much as the communities with the name of Saints of the Catholic Religion (e.g. Saint Francis, Saint Joseph, Saint Michael, Saint Anthony,

Saint Lucy) still predominate, that is, that the vast majority of Catholics were formed by the lack of deacons, priests and bishops to perform the masses, it should be noted that only from the priest onwards the celebration is complete, has contributed to the expansion of the Evangelical Religion, which only needs a good religious leader and, or, media and social actions to cover the religious void.

3.4 LIGHT FOR ALL (LPT) SOCIAL PROGRAM

The LPT of the Program for Universalization of Access to Electricity, invested 24 billion reais for the population of the Brazilian rural area, serving 3.6 million families (17.3 million people). In remote regions (all states in the North + Mato Grosso + Maranhão), 1.9 billion reais were spent, serving 52.9 thousand families (211 thousand people) (DIAS, 2024).

3.4.1 Positive points

For Reis Júnior (2015), the LPT is the boldest rural electrification program developed in Brazil, particularly for the North region, greatly allowing the improvement of the quality of life and well-being of the community members served by the program. Freitas and Oliveira (2017) state that the LPT is of great importance as a public policy for social inclusion.

In rural communities: Maranhão; São Benedito; Terra Nova and Terra Preta do Limão, located, respectively, in the municipalities of Parintins; Boa Vista do Ramos; Barcelos and Barreirinha in the state of Amazonas, it was observed that the implementation of the LPT brought benefits such as improvements in the living conditions and social well-being of the community, providing them with improved education (e.g. digital inclusion of students, night classes, high school, vocational courses); obtaining household appliances; access to treated water; a greater number of schools and, therefore, of education professionals; lighting of public and private environments (GUIMARÃES, 2021).

3.4.2 Negative Points

Reis Júnior (2015) asserts that the modernization promoted by electrification in rural communities in Amazonas has in many cases caused changes in the *habitus* of the community, especially with regard to the daily and peculiar daily life, that is, focus on work (extractivism, farming, fishing and hunting) and early evening retreat (7 pm to 8 pm) to rest, moving onto:

- Retirement to rest late at night;
- Increased consumption of alcoholic beverages;
- Noise pollution from the use of stereos and TV;

- Young teenagers with tattoos and haircuts typical of celebrities, especially sportsmen.

In addition, other problems have been observed:

- Ease of access for people outside the communities (compromising the safety of the community);
- Consumption of illicit drugs.

Furthermore, the LPT neglects other relevant points, such as environmental and socioeconomic issues (health, education and production), situations that compromise the well-being of the community, in addition to the fact that the program does not evaluate the results and impacts generated, nor does it monitor the processes (FREITAS; OLIVEIRA, 2017).

Another social problem observed is the constant lack of energy for various reasons, especially the fall of trees on the power grid in the branches, especially during rainy periods (REIS JÚNIOR, 2015).

Studying rural communities in Amazonas: Maranhão; São Benedito; Terra Nova and Terra Preta do Limão, located, respectively, in the municipalities of Parintins; Boa Vista do Ramos; Barcelos and Barreirinha, identified that the LPT, by itself, does not eliminate inequalities and other problems of a social nature, since it is observed that there are communities in which the mercantilist vision prevails in the service of electricity supply (with stimulus to consumption and, above all, profit). In addition, the LPT does not guarantee the maintenance of local culture; income generation through social programs that take advantage of local biodiversity; use of energy from renewable sources in a sustainable way, such as photovoltaic mini-plants with mini-distribution grids (GUIMARÃES, 2021).

Therefore, the LPT should urge the defense of the environment; territorialization; the socio-cultural exercises of the traditional peoples of the Amazon, especially the riverside dwellers; be more inclusive, equitable, and sustainable, thus guaranteeing them the right to citizenship (GUIMARÃES, 2021).

Although the LTP has positive and negative points highlighted in the literature consulted, it is relevant to investigate the implementation of projects aimed at freezing fruit pulp and organic materials (e.g. meat, fish and dairy products), since this represents a viable income alternative for traditional and indigenous peoples.

3.5 NEW SCENARIOS AND THE CHANGE OF *HABITUS* IN TRADITIONAL COMMUNITIES

In order to understand the changes in the scenarios of the communities and in the *habitus* of the traditional peoples of the Amazon, it is necessary to analyze the *modus vivendi*, *faciendi* e *operandi* of these populations. Leal et al. (2025) concluded that:

"(...) The ways of life of traditional Amazonian peoples and communities constitute sophisticated social and ecological engineering, capable of producing resilience, well-being, and conservation when supported by effective territorial rights, robust community institutions, and polycentric governance arrangements." (LEAL et al., 2025, p. 54).

That said, it is clarified that the *modus vivendi* refers to the socioeconomic sphere (e.g. daily life, market), to law and diplomacy (especially to the rules of coexistence) and the *modus faciendi* and *operandi* refer to the subsistence practices developed by the community members (e.g. sustainable extractivism, itinerant agriculture of floodplains and terra firme, artisanal fishing and hunting, social and territorial organization, ancestral knowledge (ethnoknowledge)) and mobility (predominantly fluvial and seasonal). These *modus* differ from each other in that *faciendi* refers to one's own way of performing an action (procedure, technique) while *operandi* is concerned with behavioral and working patterns and forms (frequent, methodical and operative) (CAÑETE; RAVENA-CAÑETE, 2010; SETTON, 2002; CAÑETE, 2023; ARAÚJO; SOUSA, 2022; ARAÚJO; SOUSA, 2023; LEAL et al., 2025; ISPN, 2026).

The interaction and integration of *Modus* The above generate the *habitus* of a population, that is, they form their culture which, in turn, is produced by the way of life, by what is done and how it is done, with the strength to oppose sudden changes, remaining and replicating. However, it should be noted that the *habitus* is always under construction due to incessant social, environmental and economic changes (SETTON, 2002; ARAÚJO; OLIVEIRA, 2014; SETTEN, 2020; ARAÚJO; SOUSA, 2023).

In this way, the environments are transformed, as seen by Araújo and Sousa (2023) when studying the TerraNostraZF5-DAS community – Manaus/AM:

"(...) built mainly with individuals from the Amazonian hinterland, it conducts in the biocultural memory the knowledge and experiences of the ancestry of the Amazonian peoples, reconstructing the landscape in a space of experience and coexistence with the biodiversity of the Amazon, constituting, therefore, the Modus vivendi associated with the Modus operandi and Modus faciendi" (ARAÚJO; SOUSA, 2023, p. 89).

Just like the *habitus*, the landscape also changes over time, consequently changing the Amazonian scenarios as seen by Araújo (2019):

"(...) the landscapes of the Amazon hinterland are configured as parts of a complex set, recognized by the interactions of man with nature, giving shape to the geographical space. In these terms, the change in the Amazonian landscape in recent centuries has occurred through historical, socioeconomic and geographical events that began in the past years of its colonization, through the exchange of knowledge and culture between colonized and colonizer" (ARAÚJO, 2019, P. 91).

The processes of change in the scenarios and in the *habitus* of traditional and indigenous communities have occurred due to factors such as agricultural expansion (deforestation) and its indirect causes (socioeconomic impacts), as seen in Canutama, Lábrea, Humaitá, Manicoré and Apuí (LIMA; MAY, 2005; CARRERO et al., 2020).

In addition, the transformations have been accelerated in recent years due to the KM, the expansion of the evangelical religion and the implementation of Light for All. These phenomena, of a natural and anthropic order, have caused significant changes in the Amazon, especially in Amazonas: droughts and severe floods in the floodplains have promoted the exodus, while access to electricity has allowed the use of technologies and the construction of religious buildings has altered the landscapes. These events have been promoting cultural allomorphies and changing the landscape and social dynamics of the community.

The photographic records made during the visits show the differences between the social organizations of the community headquarters that were previously structured with a church, social center, school, flour house and soccer field (MIGUEZ; FRAXE; WITKOSKI, 2011) with those of the present day. Currently, major changes in fundamental social rights have been seen in most of the communities visited, especially in religion (freedom of belief), education and health. These transformations create new scenarios, with emphasis on the departure of flour houses (which began to be built closer to the production units, mainly of cassava (*Manihot esculenta* Crantz) and guarana (*Paullinia cupana* Kunth)) (Figure 4) and of the Churches that, with the expansion of the Evangelical Religion, began to have more than one in the community headquarters (Figure 5).

It should be noted that the expansion of the Evangelical Religion has promoted changes both in the scenarios of the existing community headquarters and in the locality where they are inserted, contributing to the formation of new villages for reasons of religious affinities, as proven by Oliveira (2012).

In addition, depending on the population size, leadership/representativeness and political influence, it is common to find in the community centers a small place for medical care, in which medical teams are periodically present, and in the absence of these professionals, the Community Health Agents (CHA) act. It should be noted that in practically all communities there are CHAs, but not necessarily a point for care.

Figure 4

Better flour houses, oven houses on rural properties in Coari – AM. A – Oven house; B – Processing of cassava root for the production of mixed flour; C – Guarana roasting; D – Guarana in the fermentation, pulping and drying stages.



Note: the term oven house is more appropriate because it develops several cassava by-products (e.g. production of flours, bijus, tapioca), the processing of guarana, the roasting of açai seeds (*Euterpe precatoria* Mart.) (production of açai "coffee") and conilon coffee (*Coffea canephora* Pierre ex A.Froehner), production of piracuí (fish meal produced by hand), among many other activities. Source: the author.

Figure 5

Churches in the Terra Preta do Limão community in Urucurituba – AM. A – Catholic Church of Our Lady of Nazareth; B – Kerygma Evangelical Baptist Church



Source: Georgina Rodrigues da Silva.

However, it was observed during the numerous activities in the interior of Amazonas that when the community is politically relevant and has strength (it can fight for common improvements with unity, organization and articulation) they obtain successes that make advances in social infrastructure, allowing the community to improve the quality of life. As seen in many communities such as Nossa Senhora do Livramento (NSL) in Silves – AM and Terra Preta do Limão (TPL) in Urucurituba – AM (Figure 6).

The aforementioned communities have infrastructures that have altered the landscapes and also changed the *habitus* of residents with positive and negative points. In these villages there is usually more than one way to get around (by roads and rivers), small traders of essential and high-demand products, access to energy, the internet, schools (which operate in the morning, afternoon and night shifts, contributing to adult education). In addition, as particularities, the NSL has a Basic Health Unit (UBS), a multi-sport gymnasium and a handicraft workshop (Figure 7), while the TPL adds a masonry port staircase, paved roads, a community center and canteen, a wooden bridge over floodplain land and a UBS in the process of construction (Figure 8).

Figure 6

Images of one of the large areas visited, villages belonging to Itacoatiara, Itapiranga, Silves and Urucurituba, with about 208, 23, 39 and 47 communities respectively. A – Map; B – Aerial view of the area



Legend: A: 1 – Unpaved branch connecting the AM 363 road to the community; 2 – Access by river; 3 – Paved branch connecting the community to the district of Itapeçu. Blue locator = Municipalities; Red Locator = Communities. Source: Google Earth.

NSL is highly representative of the rural population of Amazonas as it is inhabited by traditional and indigenous peoples, stands out for its work with the tucumanzeiro (*Astrocaryum aculeatum* G.Mey. - Arecaceae) in the commercialization of the fruit (tucumã) and the use of the stem and leaves for the production of handicrafts, as one of the main economic activities.

It is plausible to observe the strong dynamics that have transformed small communities into medium > large > Districts/Villages (DV) (such as Novo Remanso and Lindóia in Itacoatiara and Itapeaçu in Urucurituba). Of note are the DV of Balbina (remnant of the construction of the HE of Balbina) in Presidente Figueiredo and Augusto Montenegro (Urucurituba-Velho), established after the change of seat of the municipality of Urucurituba. Prior to LC No. 230/2026, 45 DV intended to become municipalities in the state of Amazonas (SANTOS, 2026).

Figure 7

Infrastructures of great socioeconomic importance for NSL. A – Unpaved branch connecting it to BR 363 and from it to AM 010 (connecting it to Itacoatiara, the largest city in the micro-region); B – Access to the river for fishing, sightseeing/tourism and transportation; C – Multi-sport gymnasium; D – Social complex with school, UBS, social center; E – Handicraft production uni



Source: the author (A-D) and AS (E).

Figure 8

Infrastructures of great socioeconomic importance for the TPL community. A – Masonry port staircase (facilitating the use of the river for fishing, sightseeing/tourism and transportation); B – Paved road that connects TPL to the Itapeaçu DV; C – Community canteen; D – Social center; E – Plaque of technical responsibility for the UBS work; F – Long wooden bridge over floodplain soil (allowing access to nearby residents to the community headquarters)



Source: Georgina Rodrigues da Silva (A – E); The author (F).

3 CONCLUSION

In the last decade, numerous changes have been observed in the scenarios of the headquarters of traditional communities. In this process of evolution, the locations of the villages were one of the preponderant factors for them to solidify and grow or forcibly displace, since the climatic extremes that occurred in Amazonas, possibly aggravated by climate change, promoted intense movements of families and, in many cases, populations, especially in the floodplain ecosystem.

The implementation of Light for All, opening of branches, paving of existing ones and the streets of the community headquarters contribute to the migrations of families from the most basic villages to the most developed ones, aiming to improve the quality of life. In addition, advances in the road infrastructure of the communities encourage the displacement of traditional and indigenous peoples who live in the river-man-floodplain-terra firme connections. However, when the collective that lives at the terra firme-homem-rodovia interface is not supplied by a permanent drinking water supply system, that is, it suffers shortages during severe droughts, the inhabitants of the terra firme suffer as much as those of the floodplains.

The urbanizations of the rural carried out by the infrastructures developed in traditional communities, especially in large communities and in the Districts/Villages, alter the landscape

both by the buildings themselves (with different construction materials, in addition to wood, straw, tile and nail) and by the facades and paintings. Still, from the middle communities it is already possible to observe some changes such as the disappearance of the oven house, the arrival of evangelical churches and small businesses offering, among other things, alcoholic beverages and cigarettes, stimulating transformations in traditional ways of life and introducing new consumption habits.

The expansion of the Evangelical Religion in Amazonas has contributed significantly to altering the landscape both in the headquarters and in the community territory. The size of the village determines the form of the change: in large districts and towns, the transformation is marked by the construction of tents, tents or churches, while in small and medium-sized areas, depending on the lack of harmony in the coexistence between people due to the different beliefs in the collective environment, there may be in addition to new structures, the displacement of similar groups to other areas of the locality, creating new communities.

As for the *habitus* of traditional and original peoples, it was concluded that this has been the most impacted in relation to changes in the scenarios. It is affected when they migrate from the floodplain ecosystem to the upland ecosystem forcibly due to climatic adversities, among other factors. There is also the presence of evangelical churches, whose doctrines are different from each other (rituals, dishes, clothing and worldview). In addition, in some cases the holding of noisy services harms rest and the local routine. In this way, the occurrences imply changes in their *modus operandi*, *faciendi* and *vivendi*, submitting them to a cultural reconfiguration.

In this context, the implementation of Light for All, which also contributes to changes in the scenarios, is by far the one that has contributed the most to the changes in the *habitus* of the community because it makes it possible to hold night classes, the acquisition of electrical and electronic devices (e.g. televisions, cell phones, stereos) and access to the internet. allowing the knowledge of new cultures and entertainment. However, the form of these interventions is often negative because they provide nocturnal noises until late hours, drunkenness, use of illicit drugs. These activities end up attracting strangers to the community, which in some cases has its circulation facilitated by the improvement of the road network, generating insecurity, especially among the elderly.

However, knowing the problems promoted by Light for All and the improvement of road networks, many derived from the absence of the State (lack of socioeconomic and security policies), it is appropriate to observe that there have been many and great changes where energy has shown to be fundamental for improving the quality of life of traditional and native peoples, providing improvements in health, food and learning. In addition, it allows

entertainment, globalization, entrepreneurship, the use of machinery and equipment making it possible to process and preserve products for self-consumption and for sale. Thus, with these consolidated factors, it is possible to work with excursionism, such as Community-Based Tourism (CBT) in the region.

Finally, it is noted that it is necessary to organize, develop and adapt the infrastructure of the upland communities, so that it can support the migratory flow of riverside populations fleeing the disastrous impacts of extreme floods and droughts.

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ADOPTION OF ESG CRITERIA AND SOCIO-ENVIRONMENTAL RISKS IN ACCOUNTING: ANALYSIS OF BANCO BRADESCO'S COMPLIANCE WITH IFRS S1 STANDARDS

ADOÇÃO DE CRITÉRIOS ESG E RISCOS SOCIOAMBIENTAIS NA CONTABILIDADE: ANÁLISE DA CONFORMIDADE DO BANCO BRADESCO COM A NORMA IFRS S1

ADOPCIÓN DE CRITERIOS ESG Y RIESGOS SOCIOAMBIENTALES EN LA CONTABILIDAD: ANÁLISIS DE LA CONFORMIDAD DEL BANCO BRADESCO CON LA NORMA IFRS S1



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ABSTRACT

This study analyzes how Banco Bradesco integrates ESG (Environmental, Social and Governance) criteria into its accounting practices and sustainability reports, assessing its compliance with the transparency and comparability requirements of IFRS S1. In a context of growing demand for socio-environmental responsibility, the relevance of accounting practices aligned with international sustainability standards and their impacts on corporate governance and financial statements is highlighted. Considering the aspects mentioned above, as well as the disclosure of financial impacts and cash flow proposed by IFRS S1, the following question arises: How does Banco Bradesco incorporate ESG criteria into its accounting practices and sustainability reports, and to what extent do these practices meet the disclosure requirements established by IFRS S1? The research adopts a qualitative approach, using documentary analysis of Bradesco's sustainability reports and a theoretical review of ESG, IFRS S1, and governance practices in the financial sector. The results indicate that, although the bank presents initiatives aligned with ESG principles, there are still gaps in the integration of this information into financial statements. The absence of consistent quantitative metrics and the lack of standardization in the reports compromise the transparency and comparability of the information. It is concluded that, in order to fully comply with IFRS S1, Bradesco must improve its disclosure processes by integrating ESG data into financial statements in a structured and measurable manner. The implementation of auditing systems to validate ESG information is recommended in order to increase data reliability and stakeholder confidence. The study contributes to the advancement of discussions on ESG practices in the financial sector and reinforces the importance of compliance with international standards for institutional credibility.

Keywords: ESG. IFRS S1. Sustainability. Transparency.

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RESUMO

Este estudo analisa como o Banco Bradesco S.A. integra os critérios ESG (Environmental, Social and Governance) em suas práticas contábeis e relatórios de sustentabilidade, avaliando sua conformidade com os requisitos de transparência e comparabilidade da IFRS S1. Em um contexto de crescente demanda por responsabilidade socioambiental, destaca-se a relevância de práticas contábeis alinhadas a padrões internacionais de sustentabilidade e seus impactos na governança corporativa e nas demonstrações financeiras e considerado os aspectos acima e de divulgação dos impactos financeiros e do fluxo de caixa proposta pela IFRS S1 nos leva à seguinte questão: Como o Banco Bradesco S.A. incorpora os critérios ESG em suas práticas contábeis e relatórios de sustentabilidade, e em que medida essas práticas atendem aos requisitos de divulgação estabelecidos pela norma IFRS S1? A pesquisa adota abordagem qualitativa, com análise documental dos relatórios de sustentabilidade do Bradesco e revisão teórica sobre ESG, IFRS S1 e práticas de governança no setor financeiro. Os resultados indicam que, embora o banco apresente iniciativas alinhadas aos princípios ESG, ainda existem lacunas na integração dessas informações às demonstrações financeiras. A ausência de métricas quantitativas consistentes e a falta de padronização nos relatórios comprometem a transparência e a comparabilidade das informações. Conclui-se que, para atender plenamente à IFRS S1, o Bradesco deve aprimorar seus processos de divulgação, integrando dados ESG de forma estruturada e mensurável às demonstrações financeiras. Recomenda-se a implementação de sistemas de auditoria para validação das informações ESG, a fim de aumentar a confiabilidade dos dados e a confiança dos stakeholders. O estudo contribui para o avanço das discussões sobre práticas ESG no setor financeiro e reforça a importância da conformidade com normas internacionais para a credibilidade institucional.

Palavras-chave: ESG. IFRS S1. Sustentabilidade. Transparência.

RESUMEN

Este estudio analiza cómo Banco Bradesco integra los criterios ESG (Environmental, Social and Governance) en sus prácticas contables e informes de sostenibilidad, evaluando su conformidad con los requisitos de transparencia y comparabilidad de la IFRS S1. En un contexto de creciente demanda de responsabilidad socioambiental, se destaca la relevancia de prácticas contables alineadas con estándares internacionales de sostenibilidad y sus impactos en la gobernanza corporativa y en los estados financieros. Considerando los aspectos mencionados anteriormente, así como la divulgación de los impactos financieros y del flujo de caja propuesta por la IFRS S1, surge la siguiente pregunta: ¿Cómo incorpora Banco Bradesco los criterios ESG en sus prácticas contables e informes de sostenibilidad, y en qué medida estas prácticas cumplen con los requisitos de divulgación establecidos por la norma IFRS S1? La investigación adopta un enfoque cualitativo, con análisis documental de los informes de sostenibilidad de Bradesco y revisión teórica sobre ESG, IFRS S1 y prácticas de gobernanza en el sector financiero. Los resultados indican que, aunque el banco presenta iniciativas alineadas con los principios ESG, aún existen brechas en la integración de esta información en los estados financieros. La ausencia de métricas cuantitativas consistentes y la falta de estandarización en los informes comprometen la transparencia y la comparabilidad de la información. Se concluye que, para cumplir plenamente con la IFRS S1, Bradesco debe mejorar sus procesos de divulgación, integrando datos ESG de manera estructurada y medible en los estados financieros. Se recomienda la implementación de sistemas de auditoría para validar la información ESG, con el fin de aumentar la confiabilidad de los datos y la confianza de los stakeholders. El estudio contribuye al avance de las discusiones sobre

prácticas ESG en el sector financiero y refuerza la importancia de la conformidad con normas internacionales para la credibilidad institucional.

Palabras clave: ESG. IFRS S1. Sostenibilidad. Transparencia.

1 INTRODUCTION

Contemporary socio-environmental and economic transformations have required companies to modernize their governance and accounting practices, aligning them with sustainability criteria, such as ESG (Environmental, Social and Governance) parameters. In this context, a change in organizational behavior is observed, in which market, institutional, and product strategies are now integrated into the corporate identity, promoting values related to social, environmental, and governance issues. This approach contributes to the construction of intangible value and to the strengthening of the relationship with stakeholders.

The incorporation of socio-environmental aspects into the search for financial results represents an evolution in the traditional view of business, as sustainable practices are now incorporated into the daily functioning of organizations. The ESG concept, in this sense, guides the adoption of corporate strategies aimed at generating positive impacts for society and the environment. In line with this movement, IFRS S1 arises with the purpose of standardizing and qualifying the disclosure of information related to sustainability, promoting greater transparency, comparability and usefulness for decision-making.

Faced with this demand, companies have started to disclose voluntary reports containing qualitative information on performance, risks, opportunities, and strategies, with the aim of strengthening transparency and risk management. However, the growing relevance of this information has highlighted the need for standardization and quantitative measurement, especially with regard to the assessment of environmental and social impacts.

In this scenario, compliance with the requirements of IFRS S1 becomes essential, especially for financial institutions, which need to ensure the quality, reliability and comparability of their financial statements at an international level. Thus, this study investigates how Banco Bradesco S.A. incorporates ESG criteria into its accounting practices and sustainability reports, as well as the degree of adherence of these practices to the disclosure requirements established by the standard.

Considering the above aspects and the disclosure of financial impacts and cash flow proposed by IFRS S1 leads us to the following question: How does Banco Bradesco S.A. incorporate ESG criteria into its accounting practices and sustainability reporting, and to what extent do these practices meet the disclosure requirements established by IFRS S1?

The research aims to: (i) identify the ESG criteria applied by Banco Bradesco; (ii) assess the compliance of its practices with the transparency, comparability and materiality requirements of IFRS S1; (iii) analyze gaps and challenges in the implementation of a disclosure system fully aligned with the standard; (iv) investigate the impacts of the integration between financial and

sustainable information; and (v) propose recommendations for the improvement of ESG disclosures.

As a methodology, the study adopts a qualitative approach, based on literature review and documentary analysis of Banco Bradesco's Integrated Report and ESG Report, considering as reference the information disclosed until December 31, 2023. In this way, it seeks to contribute to the advancement of discussions on the integration between sustainability and accounting in the financial sector, reinforcing the importance of compliance with international standards.

2 THEORETICAL BASIS

In the introduction to the concepts, it is necessary to highlight that, as civilization has developed, with the emergence of innovations and the advance of industrial capitalism to what we know today, it becomes possible to perceive the impact of climate adversities, social unrest and disruptions in supply chains, demonstrating that environmental risks bring social and economic consequences almost inevitably.

Penna and Castro (2010) contextualize the 1950s as a period in which companies began to incorporate ethical measures in a more evident way, reflecting the recognition of the need to build companies that are not only economically viable, but also environmentally and socially responsible.

On the other hand, Tinoco and Kraemer (2004) point out that it was necessary to understand the impact of environmental degradation, which forced companies to incorporate environmental issues into their commercial objectives.

Regardless of the approach, the concept of corporate sustainability came with the idea of good practices adopted by companies that opt for ethical attitudes, aiming at economic growth that respects the environment and the sustainable development of society.

In view of this, Coral (2002) highlights the importance of companies having tools that help in the development of environmental strategies.

When the environmental issue is addressed in strategic planning, it is generally seen as a threat to the increase in production costs due to legal restrictions on the control and treatment of effluents and waste or as a threat to access to raw materials from scarce natural resources. Coral, 2002, p.135)

Thus, sustainable strategic planning emerges as a fundamental approach for companies that seek to promote environmental and social management, while maintaining their competitiveness in the market.

In this way, sustainable management plays an essential role in the implementation of this planning, not only to solve ecological and environmental problems of companies, but to promote social and governmental actions for their environment.

A survey by the United Nations Industrial Development Organization (UNIDO) points out that companies are responsible for about 60% of global greenhouse gas emissions.

However, Tchizawa (2011) points out that this impact varies according to the type of organization. The author also relates environmental management to ethical motivations, where entities seek to improve their ecological image and demonstrate concern for well-being, involving the identification, evaluation and management of the environmental impacts of their activities.

The construction of strategic purposes with a social, environmental and corporate vision has intensified, as society demands from companies a more active role in the environment in which they operate. This movement has facilitated the incorporation of responsible practices into corporate daily life, as Schroeder explains:

Companies have come to play a role that goes beyond their traditional function as providers of goods and services. In other words, society registers that, in addition to being great generators of material wealth, companies should and can also assume an expanded responsibility, getting involved in social causes. (Schroeder & Schroeder, 2004, p. 5).

Schroeder and Schroeder (2004) clarify that this demand and the transformation of corporate identity arise when society realizes that, many times, the State does not have sufficient resources and structure to guarantee the social, environmental and governmental well-being of the entire population. Thus, space is opened for strategies focused on ESG, sustainability, and corporate social responsibility to contribute to meeting part of these needs.

2.1 SUSTAINABILITY X ESG X SER:

However, environmental management is comprehensive in its performance. Therefore, a discussion on the concepts of ESG, Sustainability, and Corporate Social Responsibility (CSR) is necessary, since the terms may be conceptually similar, but diverge in focus and objective within companies.

When we mention sustainability, the most accepted concept is the one defined by the Brundtland Report of 1987, named "Our Common Future". When we talk about sustainability, we are dealing with a broad concept, whose meaning is related to the balance of present needs without compromising the ability of future generations to meet their own needs. The World Commission on Environment and Development also emphasizes the connection between

economic, social, and environmental development, as well as advocating for the adoption of practices that balance these three aspects to ensure the necessary resources.

Corporate Social Responsibility, on the other hand, involves the responsibility of companies in relation to the impacts of their decisions and activities on society and the environment, aiming to contribute to sustainable development. However, as highlighted in the scientific article "Corporate Social Responsibility: Concept, Management Instruments and Standards" of 2015, the concept of CSR does not have a universal definition. However, when we delved deeper into the literature, we identified that the concept is related to policies and actions that promote the communication of the entity's positive behavior in relation to the social and environmental sphere.

As we can see in Figure 1, it is possible to distinguish Sustainability, CSR and ESG based on the focus and objective of each concept presented:

Figure 1

ESG Focuses and Objectives, Sustainability and CSR

	ESG (Environmental, Social, and Governance)	Sustentabilidade	RSC (Responsabilidade Social Corporativa)
Foco	Criação de conjunto de critérios usado para avaliar as práticas e o desempenho de uma empresa em três áreas principais: ambiental, social e governança	Preservação dos ecossistemas e recursos naturais, concentrando - se na equidade e bem-estar das pessoas e viabilidade financeira a longo prazo.	Práticas que a empresa de ser socialmente responsável, indo além dos lucros e considerando o impacto de suas atividades na sociedade e no meio ambiente.
Objetivo	Fornecer aos investidores uma visão abrangente sobre o comportamento da empresa em relação a esses critérios, ajudando na tomada de decisões de investimento responsáveis.	Promover práticas que garantam a sobrevivência e prosperidade a longo prazo, minimizando impactos negativos e contribuindo positivamente para a sociedade e o meio ambiente.	Melhoria da imagem pública da empresa, aumentando o engajamento dos funcionários, e criar um impacto positivo nas comunidades locais e no meio ambiente.

Source: Prepared by the authors.

Therefore, we can conclude that, when we think about Sustainability and Corporate Social Responsibility (CSR) within entities, these practices tend to be more spontaneous within entities, focusing on environmental leadership and organizational initiatives, such as promoting "quality" of life within the company and volunteer programs, without necessarily integrating them with value creation and risk management.

However, when we talk about risk mapping, we are referring to ESG criteria, as they involve financial decisions based on performance and relevant environmental, social, and governance metrics, focusing on short-, medium-, and long-term performance and value creation, as well as addressing environmental, social, and governance risks.

For Tinoco and Kraemer (2004), this management has become a strategic factor for the analysis of senior management, especially in the strategies formulated to ensure compliance with environmental laws.

2.2 ESG PILLARS

Therefore, risk and strategy management requires understanding how the three pillars involving ESG are worked:

In the first criterion, Environment, entities must adopt measures to reduce their impact on the environment.

Tchizawa (2011), in his book, establishes that entities can develop their main environmental performance criteria through:

1. Greenhouse Gas (GHG) Emissions;
2. Consumption of energy and natural resources;
3. Waste management and recycling;
4. Impact on biodiversity.

The criteria of the social pillar, on the other hand, refer to the policies and actions that generate an impact on the community in which the entity is inserted. In this sense, we can consider the promotion of diversity and inclusion, the health and safety of employees, in addition to relationships with suppliers and customers.

Finally, the Governance criterion deals with the corporate governance practices adopted by companies.

In this aspect, the company's structured organizational configuration, independence in decision-making by boards, market ethics, anti-corruption, risk management, and transparency in communication with investors are evaluated.

Currently, the increase in demand for ESG strategies is justified by three factors, the first of which is linked to the fact that customers and employees are looking for companies whose values are aligned with their own.

For companies, this factor impacts engagement and productivity. Nogueira (2020) points out that when the employee recognizes the values of the company itself, a positive feeling of belonging is created in the work environment.

However, it is important to note that this factor is related to a generational issue. Nogueira (2020) observes, in his case study, that more conservative generations (X and Y) do not consider the alignment of values as relevant, prioritizing safety and individual projects. On the other hand, when analyzing the data from generation Z, the importance of alignment for maintaining the employment relationship was noted. This same alignment was pointed out in a Forbes survey, where 88% of respondents showed a tendency to buy products with social and environmental benefits and would be loyal to the brand for this reason.

Junqueira (2023), highlights the importance of communication between the entity and its audience, ensuring a stronger identification.

The second factor is the growing pressure and demand for robust ESG programs, with accurate disclosures. In 2023, B3's Corporate Sustainability Index (ISE) disclosed that companies committed to sustainable practices have an estimated market value of R\$2 trillion, which corresponds to 54% of the total value of companies listed on B3. Consequently, investors have come to recognize that the financial market can shape more sustainable companies, and this commitment is sometimes a prerequisite for listing and attracting investments.

The research carried out by Junqueira (2023) estimates that, by 2025, the ESG agenda should raise around US\$ 53 trillion in investments. In 2023, the same survey showed that 84% of executives say that ESG contributes to shaping a more robust corporate strategy, influencing mergers and acquisitions, in addition to mitigating risks of losing market share.

Finally, in recent years, new laws have emerged to reduce carbon emissions while meeting the commitments of the Paris Agreement.

In Brazil, concern for the environment gained prominence after Rio-92, an event that marked the beginning of awareness and public policies aimed at sustainability.

Thus, in recent years, there has been a significant growth in environmental management in the Brazilian territory.

For Tchizawa (2011), the first attempts to establish a "green seal" occurred during the 90s, when ABNT proposed to IBPA a project aimed at a voluntary environmental certification scheme.

Currently, ABNT promotes the adoption of the following environmental standards:

ISO 14001: International standard that specifies the requirements for an Environmental Management System (EMS). It assists in the identification of risks and controls on significant environmental aspects, promoting continuous improvement through the PDCA (Plan-Do-Check-Act) methodology.

ISO 26000: International standard that provides guidelines on social responsibility. Unlike ISO 14001, it is not certifiable, but it guides organizations on how to operate in a socially responsible manner.

According to the text of the standard, corporate social responsibility is based on seven principles: responsibility, transparency, ethical behavior, respect for the interests of stakeholders, rule of law, and human rights.

The standard also establishes guidelines on how to integrate social responsibility actions into its policies, strategies, and evaluation criteria.

The adoption of the ISO 14001 and ISO 26000 standards, promoted by ABNT in Brazil, represents a significant step for organizations that seek to align their operations with the principles of sustainability and social responsibility, integrating them as ESG criteria.

On October 20, 2023, the Brazilian Securities and Exchange Commission (CVM) disclosed, through CVM Resolution No. 193, the option to prepare and disclose sustainability-related financial information reports based on the international standard issued by the ISSB, as of the base date of 2024. However, the same resolution provides for the mandatory nature of this information for publicly traded companies as of 2026.

2.3 DISCLOSURE REPORTS

With the advent of globalization and the growing awareness of the importance of social and environmental issues, companies began to report their social and environmental performance, in addition to the respective financial impacts.

Throughout the development of environmental, social and corporate assessments and actions, the need arose to disclose this information through separate reports, with emphasis on the actions carried out by the entity during the year.

The first integrated report was created in 1997, with the initial objective of being a model capable of transmitting the transparency of the environmental impacts generated by the entity and meeting the principle of comparability, the Global Reporting Initiative (GRI) created the first mechanism that made it possible to understand the financial impacts generated by the entity's environmental and social management.

Over these 27 years, the form of disclosure proposed by the GRI has evolved, covering not only environmental issues, but also social and economic topics, becoming a comprehensive Figurework for sustainability reporting, applicable to any organization, regardless of its economic scale or sector.

The flexibility of the GRI allows companies to align their disclosures with multiple integrated reporting templates, ensuring that different stakeholders receive the information they need. Among these models, the TCFD, the GHG Protocol and, more recently, the integration with IFRS S1 stand out.

In 1998, the GHG Protocol was developed with the aim of standardizing and guiding the accounting of GHG emissions in a consistent, comparable and transparent manner.

To this end, the GHG classifies emissions into three scopes:

- **Scope 1:** Direct emissions from sources controlled by the organization (such as the burning of fossil fuels in boilers).

- **Scope 2:** Indirect emissions associated with the purchase of electricity, heat, or steam.
- **Scope 3:** Other indirect emissions along the value chain, such as transportation and use of products sold.

One of the main differentials of the GHG Protocol is the principle of completeness, that is, the report requires the disclosure of all sources of emissions, which must be listed in the entity's inventory.

The Task Force on Climate-related Financial Disclosures (TCFD) is a voluntary integrated report used to promote and develop the disclosure of climate-related financial impacts, encouraging transparency and better management of climate risks. This report helps investors and the public understand the concentration of carbon in assets.

The TCFD proposes that its disclosures be organized around four areas, as shown in Table 1:

Table 1

Key dissemination characteristics of the TCFD.

Governança	Como a Administração realiza a gestão dos riscos relacionados ao clima.
Estratégia	Como os atuais e potenciais riscos climáticos impactam as estratégias, modelo de negócio e planejamento financeiro da entidade.
Gestão de Riscos	Como a organização identifica, endereça e gere riscos relacionados ao clima.
Métricas e Metas	Quais são as métricas usadas para endereçar e gerir informações relevantes relacionadas aos riscos e oportunidades relacionadas ao clima.

Source: Prepared by the authors.

As we can see in this theoretical Figurework, there are different approaches and methodologies for environmental disclosures, which can be developed depending on the purpose of the disclosure. However, in this work, we highlight the methodology of scoping and dissemination according to the SASB as an object of study.

The requirements developed by the Sustainable Accounting Standards Board (SASB) provide entities and investors with standardized communication, relating the financial impacts of sustainability across 77 industries.

In March 2022, through the International Sustainability Standards Board (ISSB), SASB published the draft IFRS S1, which aims to standardize the general requirements for

sustainability disclosures, related to the opportunities and risks associated with an entity's sustainability.

According to the publication issued in June 2023, IFRS S1 has the scope of preparing and disseminating sustainable information related to financial information that is useful to users, such as:

- **Governance:** What are the processes, controls, and procedures that management uses to monitor and manage sustainability-related risks and opportunities.
- **Strategy:** Disclosure of the approach the entity uses to address sustainability risks and opportunities that affect operating strategies and cash flow in the short, medium and long term.
- **Metrics and Targets:** What information is used to manage the performance of sustainable risks and opportunities.
- **Risk Management:** How the entity manages sustainability-related risks

The standard also provides for the obligation that the report be prepared and disclosed at the same time as the financial statements, in addition to the inclusion of financial data and assumptions, considering the accounting standards already in force.

In addition, more recent ISSB publications on the subject provide for the particularity of IFRS S1 disclosures according to the market segment in which the entity operates.

3 ANALYSIS AND INTERPRETATION OF RESULTS

3.1 BANCO BRADESCO S.A

Banco Bradesco S.A. is one of the most traditional financial institutions in the Brazilian financial market. Founded in 1943 by Amador Aguiar, the bank aimed to serve small merchants, farmers and the population in general, especially in regions that did not have easy access to financial services.

The first practices focused on ESG occurred throughout the 1950s, with initiatives focused on education. Later, in 1988, the institution founded the Bradesco Foundation, a third sector organization with the main objective of providing education and professional training for young people and adults, offering free education, in addition to promoting digital inclusion programs.

As for integrated sustainability reports, the institution issued its first report in 2006, in line with GRI (Global Reporting Initiative) standards.

In the following years, in addition to the mandatory disclosure, Bradesco began to integrate information on important sustainability indices into its reports, such as the B3 Corporate Sustainability Index (ISE) and the Dow Jones Sustainability Index (DJSI).

In 2019, Bradesco launched its commitment to be a positive impact bank, with ambitious goals for 2025, including reducing carbon emissions and financing sustainable initiatives. This vision was consolidated with the creation of the Sustainability Committee and the inclusion of sustainability as one of the bank's strategic pillars

3.2 REQUIREMENT FOR IFRS S1 DISCLOSURE

3.2.1 General Characteristics

Regarding the general characteristics of sustainability disclosure under IFRS S1, they are similar to those defined for financial statements. According to the rule, the presentation of the report provides that, for sustainability indices to be useful, they must be relevant and faithfully represent all the risks and opportunities to which the entity is exposed, whether as a result of its employment practices and those of its suppliers, the assets (including investments) that the entity controls or its sources of financing. The information must be comparable, verifiable, timely and understandable.

The standard also requires the following general reporting characteristics:

- 1. Related Information:** An entity shall provide information that enables users to connect risks and opportunities to the entity's financial objectives.
- 2. Materiality:** An entity shall apply judgment to identify relevant sustainable information. The judgment applied in the definition of materiality must be described in the report.
- 3. Comparative Information:** An entity shall provide comparative information that reflects the updating of previously established estimates.
- 4. Frequency of Reporting:** An entity shall disclose the report as often as financial disclosures. The document points out that, normally, the entity prepares the sustainability report for 12 months. However, some entities prefer to issue reports for 52 weeks, but IFRS S1 does not contemplate this practice.
- 5. Location of Information:** Entities are required to disclose information as required by IFRS Sustainability.
- 6. Sources of Estimation and Uncertainty:** An entity shall disclose the relevant metrics and the nature of the uncertainties affecting those metrics.

7. Errors: An entity shall identify and correct material errors from previous and current years resulting from omissions and misstatements in sustainability-related financial disclosures.

8. Declaration of Conformity: An entity must include an explicit, unqualified statement of compliance if its disclosures meet all of the requirements of the standard.

The following table was prepared to identify whether Banco Bradesco follows the general characteristics of the IFRS S1 standard:

Figure 2

General Disclosure Characteristics

	2023		
Características Gerais	Apresentado	Não Apresentado	Não Aplicável
Materialidade	x		
Informações Relacionadas		x	
Informações Comparativas	x		
Frequência do Relatório	x		
Localização das informações		x	
Fontes das Estimativas	x		
Erros		x	
Declaração das conformidades	x		

Source: Prepared by the authors.

Materiality is a fundamental aspect in audit practice and in the IFRS S1 standard, because, in both cases, it influences the planning and execution of the audit, especially in the mapping of sustainable risks and opportunities. According to ISA 320, materiality is defined as the magnitude of an omission or misstatement of a financial statement that, individually or in the aggregate, can influence users' economic decisions made based on the financial statements.

Thus, materiality is determined based on percentages of relevant financial metrics, such as revenue, earnings before taxes, or equity.

In the IFRS S1 standard, the concept of double materiality is considered. According to the PWC report (2022), double materiality aims to identify relevant issues from a financial point of view, such as impact.

To assist in the identification of relevant issues of impact, the Sustainability Accounting Standards Board (SASB) has a mapping by industrial sectors that can integrate ESG. According to the SASB Standards, the relevant issues to be considered for commercial banks are highlighted in Figure 3, below:

Figure 3

Relevant Issues for the Financial Sector

Ambiente	Capital Social	Capital Humano	Modelo de Negócio e Inovação	Liderança e Governança
Emissões de GEE	Direitos Humanos e Relações Comunitárias	Práticas trabalhistas	Design de produto e gerenciamento do ciclo de vida	Ética empresarial
Qualidade do ar	Privacidade do cliente ⓘ	Saúde e Segurança dos Funcionários	Resiliência do modelo de negócios	Comportamento competitivo
Gestão de energia	Segurança de Dados ⓘ	Engajamento, diversidade e inclusão dos funcionários	Gestão da cadeia de abastecimento	Gestão do Ambiente Legal e Regulatório
Gestão de Água e Efluentes	Acesso e acessibilidade		Fornecimento de materiais e eficiência	Gestão de Riscos de Incidentes Críticos
Gestão de Resíduos e Materiais Perigosos	Qualidade e segurança do produto		Impactos físicos das mudanças climáticas	Gestão de Riscos Sistêmicos
Impactos ecológicos	Bem-estar do cliente			
	Práticas de venda e rotulagem de produtos ⓘ			

Source: SASB STANDARDS.

In addition to the table provided by sectors, the entity must evaluate its value chain in order to have the necessary information to identify environmental, social and governance issues that impact the entity's development.

IFRS S1 does not specify a materiality threshold, nor does it predetermine what would be material in a particular situation, but establishes that an entity should apply its judgment in order to identify sustainability-related financial information, and that it should be reassessed at each reporting date, considering changes in circumstances and assumptions.

As communicated in the Materiality Report (2022), Banco Bradesco reviews its materiality every two years. This report presents how the bank identifies and prioritizes relevant ESG issues within its operations and for its stakeholders. To determine material topics, Banco Bradesco uses a structured approach that includes: engagement with stakeholders, analysis of trends and risks, and internal assessments.

In 2022, the main themes identified were: sustainability and environmental management of the bank, inclusion and diversity, governance and ethics, digital transformation, and security and data protection.

During the reading of the materiality report, it was not possible to identify the assumptions used to calculate the financial impact of the entity's decarbonization projects.

Regarding the connected information, that is, how the risks and opportunities are related to the financial statements, it is observed that, in the integrated report and in the ESG report, there is a qualitative predominance, with majority descriptions of sustainability, governance, and social impact actions.

For example, in the integrated report, the entity describes its initiatives and commitments to reduce carbon emissions without necessarily associating these efforts with specific financial metrics. This is a more subjective disclosure of ESG reports, which, although it could complement the financial information in an explanatory note, does not establish a direct

quantitative connection with the financial statements, providing a comprehensive overview of corporate performance from a sustainable perspective.

As for comparative information, the entity has released its integrated report since 2020, which allows the comparability of the metrics presented.

With regard to the frequency of the report, the entity publishes its integrated report on an annual basis, which contrasts with the periodicity established in IFRS S1. Since the financial statements are disclosed quarterly, it appears that the issuance of the documents took place separately, with the financial statements published on February 6, 2024 and the integrated report on June 7, 2024.

Regarding the location of the information, the entity follows the guidelines for accountability and good sustainability practices, responding to the disclosure content proposed by the GRI Standards. This means that, in 2023, risks and opportunities were not disclosed according to the IFRS Sustainability standard.

Regarding the disclosure of the sources of estimates, in 2023 the entity presented, separately from the integrated reports, a spreadsheet of ESG indicators. The document is presented in an Excel spreadsheet, divided into three main tabs. On the main page, it is possible to see the description that the indicators cover the period from January to December 2023. It should be noted that the construction of the metrics was carried out according to the guidelines of the GRI Standards, Integrated Reporting of the Value Reporting Foundation (IIRC), in addition to considering global methodologies and Figureworks. As for the metrics, they were formulated based on the ESG pillars. In the environmental pillar, there are 83 indicators, subdivided into sub-themes such as operational emissions, water, energy, waste and material management. It is possible to verify that the company uses financial criteria, such as net revenue, to calculate the indicators of emission intensity and energy intensity. However, the methodology applied and the uncertainties of the estimates are not clearly described, especially in relation to the indicators of the governance and social pillars, which are more subjective in nature.

Regarding uncertainties, it is relevant to mention that, in July 2024, IFRS Accounting published the Exposure to Climate Uncertainties and Other Uncertainties in Financial Statements project. In this document, IFRS Accounting proposes eight examples that illustrate how an entity can apply the requirements of IFRS Accounting Standards to report the effects of uncertainties related to climate or other sustainable topics in its financial statements, focusing on areas such as materiality judgment, disclosures on assumptions and uncertainties of estimates.

As observed in the indicator spreadsheet, two errors were reported: the first, related to the calculation of employees entitled to maternity/paternity leave, and the second, related to the amount of own social and environmental products. In both cases, the error was identified and recalculated, but it was not mentioned whether there was a material financial impact after the new measurement.

Regarding the declaration of conformity, the limited assurance was carried out by KPMG - Auditores Independientes. As disclosed, the auditors conducted the work in accordance with Technical Communiqué CTO 01 - Issuance of an Assurance Report Related to Sustainability, issued by the Federal Accounting Council, and NBC TO 3000 - Assurance Engagements Other than Audit and Review. These standards regulate the planning and execution of work, with the objective of obtaining limited certainty about the non-financial information presented in the ESG Report.

The assurance report emphasizes that the opinion is conditioned by the fact that non-financial data is subject to inherent limitations.

3.2.2 Governance

The purpose of the entity disclosing about Governance is to allow users to understand the processes, controls and procedures that Management uses to monitor and manage risks and opportunities related to sustainability.

To this end, the entity must disclose information about the councils that deliberate on sustainability risks and opportunities and how this process is managed. For the standard, the entity must disclose:

- A) What is the identity, skill and competence of the board members responsible for sustainability risks and opportunities;
- B) How and how often the group conducts assessments on sustainability issues;
- C) How does the responsibility of this group reflect on the entity or company?
- D) How the board (committee) controls and monitors at the management level applied to risks and opportunities and how they are related to financial metrics, including compensation policies.
- E) How sustainability-related risks and opportunities are linked to the entity's strategies.

In view of the above requirements, a Figure work was prepared so that we could analyze the 2023 integrated report and verify whether the above items were applied or not:

Table 2*Governance in the Bradesco S.A Integrated Report*

	Year 2023	
Governance	It does not proceed	Proceeds
Item A	X	
Item B		x
Item C		x
Item D		x
Item E		x

Source: Prepared by the author.

Item A addresses who the board members are and what their skills and competencies are in relation to risk and opportunity management. At the strategic level, Bradesco, within its board of directors, has a sustainability and diversity committee, whose main responsibility is to monitor and implement the sustainability strategy. However, the report does not feature the members of the sustainability committee.

Banco Bradesco presents in its ESG Report the governance structure, which we can identify and relate the corporate governance relationships that assist in the development and monitoring of strategies, risks and opportunities.

Item B deals with the frequency with which the committee meets to monitor sustainability-related risks and opportunities. In 2023, the entity informed that the sustainability and diversity committee meets bimonthly.

Item C discusses how the monitoring of these risks and opportunities is integrated into the company's structure. For Banco Bradesco, governance is integrated, which means that decisions made at the executive level reflect on the other organizational levels, for example, at the executive level, the entity has a sustainability committee, whose objective is to advise on the strategic level decisions of the sustainability and diversity committee, proposing strategies and solutions that promote the adoption of the best corporate sustainability practices in the entity's business activities.

Item D addresses how management controls and monitors, at the management level, risks and opportunities, relating them to financial metrics, including compensation policies. At the operational level, the entity has a sustainability area, responsible for developing, proposing and monitoring indicators and actions for the implementation of the sustainability strategy, advising the board of directors, the committee and the commission in their duties. In the variable

compensation process of executives and in the evaluation of their respective areas, ESG aspects and performance in the main sustainability indices and ratings are considered.

Finally, Item E discusses how strategies related to risks and opportunities are aligned with the entity's overall strategy. Through the sustainability area, the entity seeks to monitor the risks and opportunities in the other structures, supporting the integration of the topic into the business. The entity has dedicated teams in different areas of the business that strive to connect and disseminate the sustainability strategy.

3.2.3 Strategies

The entity's objective in disclosing its strategies is to enable users to understand how it addresses risks and opportunities related to sustainability. To achieve that objective, an entity shall disclose information on:

a) The relevant sustainable risks and opportunities that may reasonably affect the business model, strategies and cash flow in the short, medium and long term. At this point, it is relevant that the entity provides a detailed description of the significant risks and opportunities. As for the deadline, the definition of strategies must be related to strategic planning and may depend on several factors, such as the type of industry, cash flow, the budget cycle, and the expected duration of capital investments, among others.

(b) the effects of significant risks and opportunities on the business model and value chain. An entity shall disclose information that enables users to understand the assessment of the impact of current and anticipated sustainability risks and opportunities on the business model. To do so, it must describe the present and projected effects of risks concentrated in the value chain. At this point, it is important to emphasize the relevance of the entity adopting an outside-in perspective, that is, not only knowing the processes and controls that can have a sustainable impact, but also considering its suppliers and customers as part of the impact generated by the company.

(c) the effects of significant risks and opportunities on strategies and decision-making. The entity must report how it responds to these risks and opportunities, bringing qualitative and quantitative data on the plans disclosed in previous reports.

The financial impact of sustainability risks and opportunities is considered in strategic decision-making, such as the location of a new branch, addressing the environmental impact of this new location, job creation and the factors that influence the company.

(d) the effects of significant risks and opportunities on position, financial performance and cash flow in the reporting period, as well as the anticipated projection of those effects in the

short, medium and long term – including how sustainability-related risks and opportunities are incorporated into the entity's financial plan. By way of example, an entity needs to disclose the exposures that occur when there are changes in revenue or costs that may result from the introduction of a Net Zero strategy, or what the impact has been on its costs by supporting labour retention strategies.

e) The ability to adjust the estimates of sustainability risks and opportunities. An entity shall disclose, in a qualitative or, where applicable, quantitative manner, analyses on strategies and cash flow related to significant risks and opportunities, including how such analyses were carried out and the base date of the study. The standard emphasizes that, when providing qualitative information, the entity may disclose the total amount or a range related to the risk.

Other IFRS Sustainability Disclosure Standards will specify the mandatory information that an entity needs to disclose. In item 3.2.6 of this work, mandatory disclosures for the financial services sector will be mentioned.

It is worth mentioning that, when relating their strategies to risks and opportunities related to sustainability, companies can opt for generic corporate strategies. Tchizawa (2011) reflects that entities such as Banco Bradesco S.A. tend to direct their strategies towards:

- A) The acceleration of the massification of digital services and the emptying of bank branches;
- B) The diversification of its financial products to attract and retain customers; e
- C) Efficiency in data storage as an element to provide exclusive services to its customers.

Next, in Figure 4, we will analyze how Banco Bradesco presents its sustainability strategies.

Figure 4

Bradesco S.A.'s Strategic Sustainability Fronts

Objetivos e decisões	Discriminação	Indicadores
Cidadania financeira	Promover educação e inclusão financeira para alavancar o desenvolvimento socioeconômico	- Valor total investido pela Fundação Bradesco para o desenvolvimento de suas atividades - Total de doações e patrocínios viabilizados por recursos próprios.
Agenda climática	Garantia que os nossos negócios estejam preparados para os desafios climáticos conscientizados engajados em seus clientes quanto a riscos e oportunidades.	- Escopo 1 - Escopo 2 - Escopo 2
Negócios sustentáveis	Impulsionar negócios de impacto positivo que fomentem o desenvolvimento socioambiental.	- Volume total de ativos sob gestão - Assets under Management (AuM) com avaliação ESG - Total de ativos com avaliação ESG sujeitos à triagem ambiental ou social positiva - Companhias que podem ocasionar dependência química e ou riscos ou danos à saúde - Companhias que produzem ou comercializam produtos de combustíveis fósseis - Companhias que podem ocasionar riscos à saúde ou à segurança alimentar e nutricional

Source: prepared by the authors.

In February 2024, the entity reinforces its sustainable development strategy through initiatives that generate positive impacts, focusing on three main fronts:

- A) Social and environmental products:** the entity offers financing for the purchase of hybrid and electric vehicles, solar energy panels and, in partnership with BNDES, provides differentiated interest rates so that rural landowners can recover pastures and forests, in addition to promoting technologies that contribute to the reduction of greenhouse gas emissions.
- B) ESG operation:** as part of its business strategy, the entity has operations to grant financing or refinance assets that contribute to the ESG agenda.
- C) Funding with IFC:** the entity has a financial agreement with the IFC (International Finance Corporation) with the objective of supporting projects aligned with ESG and financial inclusion principles, expanding support to micro, small and medium-sized companies inserted in the context of Local Productive Arrangements (APLs).
- D) Responsible investments:** through a screening that incorporates ESG analysis data into strategies for assessing relevant risks and opportunities within funds and assets. In addition to the use of ESG criteria as a way of incorporating assets, the entity offers asset funds that have projects related to the ESG theme.

In 2023, these funds under management of Banco Bradesco that have integration of ESG issues, totaled a net worth of R\$ 315 million.

Regarding the IFRS S1 standard, we can observe that the report does not provide specific information, not allowing an in-depth analysis of the financial impact of these initiatives. In addition, the document also does not present long-term cash flow projections, which prevents a clear understanding of how the management of these assets influences the entity's operating cash flow.

3.2.4 Risk Management

According to ISO 31000, risk can be defined as the effect of uncertainties on planned objectives.

In this sense, environmental risk is considered by the identification, measurement, and disclosure of an environmental, social, or governance event that generates environmental costs, assets, or liabilities, directly impacting the company's profitability.

This management is carried out by understanding significant sustainable events that may reasonably affect the entity's assets, liabilities or cash flow.

According to Raoni (2024), for the assessment of risks related to sustainability, the entity needs to observe the positive and negative impacts (actual and potential) it has on the economy, the environment, and human rights. After the identification of the impact (event), the entity shall assess the frequency of the occurrence of that impact. The entity can use methodologies that help calculate the frequency, however, in cases of real impact (an impact that has already occurred), it is only necessary to assess the severity, that is, the magnitude of this identified event.

By assessing severity and combining it with an assessment of the frequency of events, the entity is able to more accurately identify the sustainability-related risks and opportunities that surround it.

According to IFRS S1, the purpose of risk management disclosure is to enable users to understand the process of identifying, assessing, prioritizing and monitoring sustainability-related risks and opportunities, including where and how these processes are integrated into the entity's risk management.

To this end, the entity must disclose information, especially on how the process is carried out and the policies used so that employees can identify, assess and monitor risks related to sustainability.

This information should include:

1. The parameters that the entity uses;
2. How the entity uses and monitors scenarios to analyze sustainability-related risks;

3. How the entity assesses the nature, likelihood and magnitude of the effects of those risks;
4. How the entity prioritizes sustainability-related risks over other types of risks;
5. How the company monitors sustainability-related risks and whether there is a change in these risks;
6. How the entity changed these parameters and how they compare with the risks reported in previous periods.

The following Figure 5 was prepared to analyze whether Banco Bradesco follows the recommendations for risk management disclosure according to the IFRS S1 document:

Figure 5

Adherence to risk management recommendations

	2023	
Gestão de Riscos	Apresenta	Não Apresenta
Critério 1	X	
Critério 2	X	
Critério 3	X	
Critério 4	X	
Critério 5	X	
Critério 6		X

Source: Prepared by the authors.

Criteria 1, 2 and 3 refer to the disclosure of parameters for the assessment of risks and opportunities related to sustainability. In 2024, the entity disclosed, in its Social, Environmental and Climate Risks and Opportunities Report (RSAC), that its sustainability-related risks and opportunities come mainly from its business relationships, including suppliers and customers, through financing and investment activities. As presented in the RSAC, the entity has a process for identifying, assessing and classifying social and climate risks, carried out through the analysis of credit and financing activities, project financing, guarantees, suppliers and investments.

In Figure 6, it is possible to see the scope of assessment of risks and opportunities related to Banco Bradesco's sustainability.

Figure 6

Description of the process of identification, measurement and evaluation of social risk, environmental risk and climate risk

Atividade	Escopo da Avaliação (Critérios)	Escala de Rating
Crédito	Score ASG: Biodiversidade, clima, direitos humanos, conformidade legal e saúde ocupacional.	Mínimo a Muito Alto (5 níveis)
Projetos	Checklists setoriais: Licenciamento, estudos ambientais, mitigação de impactos e exposição climática.	Mínimo a Muito Alto (5 níveis)
Garantias Imobiliárias	Passivos ambientais, contaminação de solo, restrições sociais e climáticas (imóveis rurais/urbanos).	Liberado, Restritivo ou Impeditivo
Fornecedores	Auditoria em três dimensões: Responsabilidade social, meio ambiente e saúde/segurança.	Mínimo a Muito Alto (5 níveis)
Investimentos	Alinhamento com frameworks globais (PRI, TCFD, IPC, AMEC) e impactos ASG nos ativos.	Baixo, Moderado ou Alto

Source: Social, Environmental and Climate Risks and Opportunities Report - Banco Bradesco.

In addition, the entity has developed criteria for exposure to social, environmental and climate risks for its potential customers, to whom credit is granted.

For social risks, criteria from IFC, S&P, as well as data on fines and child labor in Brazil are used.

Environmental risks are classified according to the same references, in addition to FEBRABAN's definitions and regulatory records. The assessment of climate risks depends on sectoral and geographical characteristics, due to the lack of specific regulation. As for the transition to a low-carbon economy, market, reputational, regulatory and technology risks are assessed.

In criterion 4, the entity seeks to disclose how these risks are prioritized over other operational risks. However, for the entity, RSACs are directly connected. Thus, aiming at this connectivity, the entity adopts stress tests to evaluate scenarios with uncertainties caused by social, environmental and climatic factors.

Scenario Analysis:

Climate change associated with greenhouse gases and temperature changes can cause changes in the macroeconomic scenario. With this in mind, Banco Bradesco conducts financial impact tests if environmental risks materialize, based on the macroeconomic equilibrium model, aiming at a comprehensive understanding of the potential impacts on portfolios, results and liquidity ratios.

Sensitivity Analysis:

In order to measure the exposure of operations with corporate customers, the entity conducts simulations to assess the impact of environmental and social risks on the granting and liquidity of credit. These simulations allow Banco Bradesco to estimate possible impacts on variables such as companies' credit ratings.

Criterion 5 is related to risk monitoring, that is, how the identified risks are managed and monitored and how the changes that eventually need to be made are detected. As disclosed in the Social, Environmental and Climate Risks and Opportunities Report (2023), the entity's monitoring includes the periodic review of social and environmental ratings. The sustainability area monitors social and environmental infractions that, depending on the event identified, result in an emergency rating review.

This area also monitors political and legal changes, and, when identified, evaluates the impacts and makes the appropriate Figureworks.

Criterion 6 was not presented as the entity did not disclose any changes in its risk assessment criteria.

Although the entity presents the risks and opportunities related to sustainability, it is emphasized that this analysis was made based on the Social, Environmental and Climate Risks and Opportunities Report, a separate management report, which is not part of the integrated ESG report disclosed. Separate disclosure may compromise the reliability of the information presented. According to IFRS S1, presentations must be carried out in an integrated manner, ensuring that stakeholders have complete information about the risks and their implications.

3.2.5 Metrics and Goals

The purpose of disclosing metrics and targets is to enable users to understand performance in relation to sustainability-related risks and opportunities.

In accordance with IFRS S1, the entity must clearly report all metrics relevant to the environment in which it operates, disclosing the methodology, the assumptions assumed, the limitations in carrying out the study, the period, the relevant milestones during the period and, if applicable, the relationship with other metrics.

It is necessary to disclose the performance, analyzing the context of the operation to which the metric is related and, in case of change, the change must be disclosed and clarified.

The analysis of Bradesco's sustainability reports revealed that, although the institution adopts ESG information disclosure practices, there are specific gaps in the integration of this information with the financial statements, such as the absence of quantitative metrics on social and environmental impacts.

The document is presented in an Excel spreadsheet, divided into three main tabs, however, on its main page, it is possible to observe the description that, as disclosed, the indicators report data from January to December 2023. It should be noted that the construction of the metrics was carried out in accordance with the guidelines of the GRI Standards and the

Integrated Reporting of the Value Reporting Foundation (IIRC), in addition to considering guidelines, methodologies and global Figureworks. Regarding the metrics, they were formulated according to the pillars of ESG.

In the environmental pillar, there are 83 indicators, subdivided into sub-themes on operational emissions, water, energy, waste and material management. It is observed that the company uses financial criteria, such as net revenue, to calculate the indicators of emission intensity and energy intensity; However, the methodology applied is not clear, as well as the uncertainties of the estimates, and the other criteria, as well as those applied to the governance and social pillars, have a more subjective nature.

3.2.6 Required Disclosures

Commercial banks carry out deposit transactions and loan concessions to individuals and companies.

As explained during the presentation of the analyses, we can observe that the risks and opportunities related to sustainability affect the macroeconomic scenario and, consequently, these operations, especially those related to the granting of credit. Given the relevance of the topic, in June 2023, IFRS Sustainability released a mandatory disclosure guide for banks.

In the document there is only one theme and metric to be disclosed on sustainability on a mandatory basis, as shown in Table 9:

Table 3

Themes and metrics of the information to be disclosed on sustainability

Theme	Metric	Category
Incorporating environmental, social, and governance factors into credit analysis	Description of the approach for incorporating ESG Factors	Reviews and commentary

Source: IFRS Sustainability.

Banco Bradesco can contribute externally, positively or negatively, through its credit granting practice. For this reason, integrating ESG factors into the grant makes it possible to determine the quality of the guarantees.

Therefore, the entity must disclose the methodology for calculating the granting of credits, as well as the policies that determine the incorporation of ESG factors in its credit analyses.

As analyzed in the Social, Environmental and Climate Risks and Opportunities Report, the incorporation of ESG factors is used, for the most part, in exposure to credit operations.

With regard to the granting of credit, the entity evaluates customers who operate in sectors with potential environmental and social exposure, resulting in a socio-environmental rating determined in credit deliberation forums, following the delimitation of the RAS. In the RAS, social, environmental, and climate risks are represented by guidelines related to sensitive sectors, controversial activities, and socio-environmental infractions that are linked to the entity's strategies.

In 2023, Banco Bradesco's exposure was characterized by credit operations, debt securities and operations not accounted for in the prudential balance sheet (transactions that are not directly disclosed by the bank, but that have risks, such as some guarantees and future commitments).

The sectors most susceptible to risks include: Financials (23.14%), Retail (4.36%), Transportation and Concession (3.42%), Wholesale (2.16%) and Real Estate and Construction (2.72%). It is important to note that the individual (39%) is not evaluated, but the report does not provide justification for this exclusion.

All economic sectors are exposed to events that can increase or decrease their social, environmental and climate risks. In 2023, the entity recognized operating losses of R\$ 3.3 million resulting from these events.

Despite the disclosure, this information was analyzed from the Social, Environmental and Climate Risks and Opportunities Report, which is a separate management document and is not part of the ESG report.

It was not possible to identify the balance recognized as an operating loss in the financial statements, which creates uncertainty about the calculation of the provision. This is because these risks may not have been considered during the assessment by the external audit.

Fragmented disclosure can compromise the reliability of the information presented. According to IFRS S1, presentations must be made in an integrated manner, ensuring that stakeholders have access to complete information about the risks and their implications.

4 FINAL CONSIDERATIONS

This study analyzed how Banco Bradesco S.A. incorporates ESG criteria into its accounting practices and sustainability reporting, with the objective of assessing the compliance of these practices with the disclosure requirements established by the IFRS S1 standard. Based on the theoretical review and analysis of the bank's reports, we sought to investigate the hypothesis that, although Bradesco adopts ESG disclosure practices, there are still gaps in the

integration of this information into the financial statements, which would compromise the transparency and comparability of the data.

The research confirmed the initial hypothesis, showing that Bradesco implements relevant practices for compliance with ESG guidelines and makes use of detailed reports on sustainability and corporate governance. However, it was observed that the full integration of this information with the financial statements is still partial. Disclosures related to social and environmental aspects, although aligned with standards such as GRI and ISSB, are not fully integrated into financial reports, which limits the ability of stakeholders to understand the financial impact of the bank's sustainable actions.

Another critical point identified was the lack of clear and standardized quantitative metrics in ESG reports. Although the bank provides qualitative descriptions of its initiatives, the absence of numerical data makes it difficult to accurately measure financial and socio-environmental impacts, a key aspect to meet the materiality, comparability and verifiability criteria of IFRS S1.

The analysis also revealed practical challenges in implementing IFRS S1 requirements, such as the need for a robust data integration system and the difficulty in quantifying the impacts of sustainable practices consistently. These factors reinforce the complexity of aligning ESG disclosure practices with global IFRS standards, requiring the bank to consider investments in measurement and control processes.

To improve compliance with IFRS S1, it is recommended that Banco Bradesco invest in the standardization of its ESG metrics, with a focus on quantitative data that can be easily integrated into the financial statements. The adoption of an independent auditing and verification system for ESG data can increase the reliability and transparency of disclosures, promoting greater stakeholder trust and alignment with international best sustainability practices.

In conclusion, the survey confirms the relevance of ESG criteria for Banco Bradesco and its commitment to sustainability. However, to achieve full compliance with IFRS S1 and meet the growing demands for transparency and social and environmental responsibility, the bank must adopt measures that reinforce the integration of ESG data with financial information, promoting reports that are both complete and comparable in the international scenario.

In addition, it is recommended that this study continue, given the growing relevance of the theme.

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BETWEEN IDEALIZATION AND SUSPICION: DESIRE AND JEALOUSY IN SENILITY AND DOM CASMURRO

ENTRE A IDEALIZAÇÃO E A SUSPEITA: DESEJO E CIÚME EM SENILIDADE E DOM CASMURRO

ENTRE LA IDEALIZACIÓN Y LA SOSPECHA: DESEO Y CELOS EN SENILIDAD Y DOM CASMURRO



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ABSTRACT

This article proposes a comparative reading of *As a Man Grows Older*, by Italo Svevo, and *Dom Casmurro*, by Machado de Assis, considering the similarities in the representation of amorous desire, jealousy, and male subjective instability. The study is based on the problem of affective relationships mediated by rivalry and idealization, recurrent in both narratives. Its objective is to analyze how Emilio Brentani and Bento Santiago construct love relationships permeated by suspicion, imaginative projection, and the inability to recognize female alterity. To this end, a comparative bibliographic and interpretative analysis is carried out, mainly grounded in René Girard's theory of mimetic desire, as well as critical studies concerning the novels analyzed. Thus, it is observed that the protagonists progressively replace real women with imaginary constructions produced by their own subjective anxieties, making jealousy a central element of identity destabilization. It is also observed that, in *Dom Casmurro*, jealousy surpasses the thematic level and comes to structure Bento Santiago's memorialistic narrative itself. It is therefore concluded that both novels represent love as an experience marked by rivalry, imagination, and the fragility of modern subjectivities.

Keywords: Mimetic Desire. Jealousy. Machado de Assis. Italo Svevo. Love Relationships.

RESUMO

O presente artigo propõe uma leitura comparativa dos romances *Senilidade*, de Italo Svevo, e *Dom Casmurro*, de Machado de Assis, considerando as aproximações existentes na representação do desejo amoroso, do ciúme e da instabilidade subjetiva masculina. Parte-se da problemática das relações afetivas mediadas pela rivalidade e pela idealização, recorrentes nas duas narrativas. Objetiva-se analisar de que maneira Emilio Brentani e Bento Santiago constroem relações amorosas atravessadas pela suspeita, pela projeção imaginativa e pela dificuldade de reconhecer a alteridade feminina. Para tanto, procede-se a uma análise

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comparativa de caráter bibliográfico e interpretativo, fundamentada principalmente na teoria do desejo mimético de René Girard, além de contribuições críticas acerca das obras analisadas. Desse modo, observa-se que os protagonistas substituem progressivamente a mulher real por construções imaginárias produzidas por suas próprias inquietações subjetivas, fazendo com que o ciúme se torne elemento central de desestabilização identitária. Observa-se ainda que, em *Dom Casmurro*, o ciúme ultrapassa o plano temático e passa a estruturar a própria narrativa memorialística de Bento Santiago. Conclui-se, portanto, que ambos os romances representam o amor como experiência marcada pela rivalidade, pela imaginação e pela fragilidade das subjetividades modernas.

Palavras-chave: Desejo Mimético. Ciúme. Machado de Assis. Italo Svevo. Relações Amorosas.

RESUMEN

El presente artículo propone una lectura comparativa de *Senilidade*, de Italo Svevo, y *Dom Casmurro*, de Machado de Assis, considerando las aproximaciones existentes en la representación del deseo amoroso, de los celos y de la inestabilidad subjetiva masculina. Se parte de la problemática de las relaciones afectivas mediadas por la rivalidad y la idealización, recurrentes en ambas narrativas. El objetivo es analizar de qué manera Emilio Brentani y Bento Santiago construyen relaciones amorosas atravesadas por la sospecha, la proyección imaginativa y la dificultad de reconocer la alteridad femenina. Para ello, se realiza un análisis comparativo de carácter bibliográfico e interpretativo, fundamentado principalmente en la teoría del deseo mimético de René Girard, además de aportes críticos sobre las obras analizadas. De este modo, se observa que los protagonistas sustituyen progresivamente a la mujer real por construcciones imaginarias producidas por sus propias inquietudes subjetivas, haciendo que los celos se conviertan en un elemento central de desestabilización identitaria. También se observa que, en *Dom Casmurro*, los celos sobrepasan el plano temático y pasan a estructurar la propia narrativa memorialística de Bento Santiago. Se concluye, por tanto, que ambas novelas representan el amor como una experiencia marcada por la rivalidad, la imaginación y la fragilidad de las subjetividades modernas.

Palabras clave: Deseo Mimético. Celos. Machado de Assis. Italo Svevo. Relaciones Amorosas.

1 INTRODUCTION

Love, desire and jealousy are recurrent themes of the Western novelistic tradition, often associated with the representation of subjectivities crossed by affective instability and the experience of rivalry. In this perspective, we propose the comparative reading of *Senility*, by Italo Svevo, a novel from the late nineteenth century, and *Dom Casmurro*, by Machado de Assis, published in the early twentieth century, as narratives that problematize love desire from a male perspective marked by idealization, suspicion and jealousy. These works present significant approximations with regard to the psychological construction of the protagonists, the problem of jealousy and the ambiguous representation of love relationships, aspects that can be verified at different levels of the narrative.

Our objective is not to carry out a strictly structuralist reading of the works, but to highlight important approximations in the narrative configuration and in the representation of male subjectivities. In the texts analyzed, the narrative focuses on a small number of characters and privileges less the external action than the exploration of the internal conflicts of its protagonists. In this way, love relationships become privileged spaces for the manifestation of desire, jealousy and identity instability, elements that cross the male affective experience in both narratives.

The indispensable preliminaries of these two stories of passion present male protagonists marked by loneliness, maturity and insertion in the urban bourgeois universe. In *Senility*, we find Emilio Brentani, a thirty-five-year-old man, an intellectual of modest prestige, recognized more for an aura of erudition than for concrete achievements, in addition to occupying a bureaucratic job of little relevance in an insurance company. In *Dom Casmurro*, we have Bento Santiago, a mature and introspective narrator, belonging to the carioca elite, whose trajectory is marked by the attempt to memorialistically reconstruct his love and marital past, in a narrative crossed by jealousy, distrust and the constant oscillation between memory and imagination. Although distinct in their social trajectories, Emilio and Bento are close by the instability of their subjectivities and by the tendency to convert love desire into idealization, suspicion and rivalry. Unable to sustain affective relationships based on otherness and trust, both transform the love experience into a space of identity destabilization.

On the other hand, the duo of female protagonists presents young, beautiful women deeply marked by the male gaze that narrates or interprets them. In *Senility*, Angiolina Zarri is described as a seductive young woman, full of vitality and surrounded by rumors about her love life. In *Dom Casmurro*, Capitu initially appears as Bento Santiago's adolescent neighbor, characterized by her intelligence, vivacity and, above all, by the mystery inscribed in her famous "hangover eyes". In both novels, these female characters are constructed less by their own

voice than by the male perspective that observes, idealizes them and, subsequently, comes to distrust them.

The two women distinguish themselves from their male peers by demonstrating greater adaptation to the social and affective world. While Emilio Brentani and Bento Santiago reveal subjectivities marked by instability and the inability to sustain affective relationships not mediated by rivalry, Angiolina and Capitu appear associated with vitality, spontaneity and a certain autonomy in the face of social conventions. Feminine beauty thus becomes the first element to awaken in the protagonists an intensely idealized desire, which gradually becomes suspicion, restlessness and identity destabilization.

The description of Angiolina evidences this feminine idealization constructed through the eyes of Emilio Brentani:

Angiolina, **a blonde with large blue eyes, tall and strong, but slender and flexible, a body illuminated with life**, a pale amber color sprinkled with the rosy of good health, walked by her side, with her head tilted to one side as if hanging from the weight of the gold that enveloped her, eyes fixed on the ground that she touched at every step with the tip of her elegant parasol as if she wanted to make a sprout from it a comment on the words he heard. (SVEVO, 1982, p.13, emphasis added)

(...) The woman [Angiolina] had awakened him! **Radiant with beauty and youth, it should illuminate her all, making him forget the sad past of desire and loneliness**, and promising her joy in a future that she, it is certain, would not compromise. (SVEVO, 1982, p.13, emphasis added)

In the Machadian novel, Capitu is also initially filtered by the idealizing gaze of Bento Santiago:

He couldn't take his eyes off that fourteen-year-old creature, tall, strong, and full, cramped in a half-faded calico dress. Her thick hair, made in two braids, with the ends tied to each other, in the fashion of the time, ran down her back. Brunette, light and large eyes, straight and long nose, she had a thin mouth and a wide chin. (ASSIS, 2019, pp.30-31)

In both narratives, the first portrait of the female protagonists focuses mainly on the physical description and youthful vitality, elements responsible for awakening desire and amorous idealization in the male protagonists. However, such descriptions do not reveal the interiority of these women, but rather the projection of the male gaze that observes, interprets and progressively transforms them into an object of fascination and restlessness.

Unlike the idealized representation of female protagonists, Emilio Brentani and Bento Santiago are presented as men marked by the oscillation between idealization and distrust. Emilio recognizes in himself "a great fear of himself and of the weakness of his own character"

(SVEVO, 1982, p.11-12), while Bento Santiago reconstructs his narrative constantly crossed by doubt, distrust and the inability to reach any definitive certainty about Capitu's fidelity. In both narratives, the female figure becomes progressively crossed by the imaginative projections of the protagonists, ceasing to exist as a fully accessible alterity.

Although constructed in different social contexts, Emilio Brentani and Bento Santiago are close because of the difficulty in establishing balanced affective relationships. From the social point of view, Mr. Brentani is a petty-bourgeois intellectual, whose notoriety derives above all from a novel written in his youth. Psychologically, however, he reveals himself to be a fragile man, unable to face reality without resorting to self-deception. Taking shelter in the domestic routine and in the protection of his sister Amalia, the Svevian protagonist finds in Angiolina the embodiment of the vitality and plenitude that he feels he lacks in himself.

Bento Santiago's memorialistic account is organized under the sign of suspicion and perceptual instability. His writing reveals a narrator incapable of sustaining the ambiguity of human relationships, gradually converting his love for Capitu into obsessive distrust. The character then ceases to exist as a fully accessible alterity, starting to be interpreted as an enigmatic figure on which Bento projects his concerns and fantasies. At a certain point in the narrative, the narrator himself recognizes his fragility in front of the character when he states that "Capitu was Capitu, that is, a very particular creature, more of a woman than I was a man" (ASSIS, 2019, p. 55), revealing a subjectivity deeply marked by insecurity and a sense of inadequacy.

In this sense, both Emilio and Bento show difficulty in recognizing female otherness, idealizing and simultaneously distrusting the women they love. The love relationship thus becomes a privileged space for the manifestation of their emotional fragilities and their unstable identity processes.

In the case of Emilio Brentani, this fragility is also manifested in a deeply pessimistic view of himself, recognizing in his personality the inadequacy that prevents him from fully living his affective relationships. In two distinct moments of the narrative, the protagonist evidences the painful awareness of his insecurity:

At the age of thirty-five he still found in his soul the unsatisfied flame of pleasure and love, and already the bitterness of not having enjoyed them, while in his brain a great fear of himself and of **the weakness of his own character**, which he really suspected more than he knew from experience. (SVEVO, 1982, pp.11-12, emphasis added)

Later on, Emilio intensifies this negative self-perception by concluding that "He rose from the wall calmer, but more dejected than when he had sat down. He was to blame. **He was the**

one who was a strange, sickly individual, and not Angiolina. And this demeaning conclusion accompanied him home." (SVEVO, 1982, p.106, emphasis added).

As evidenced, the protagonists of *Senility* and *Dom Casmurro* have real difficulties in establishing balanced affective relationships. Emilio, unable to take control of his own emotional life, projects onto Angiolina the promise of happiness and fulfillment that he cannot find in himself. In a similar way, Bento Santiago, dominated by suspicion and perceptual instability, builds his relationship with Capitu from a continuous movement of idealization and distrust, revealing a subjectivity deeply marked by insecurity and the need for control.

While Emilio hopes that Angiolina will erase his past of frustrations and loneliness, Bento Santiago tries to memorialistically reconstruct a love relationship that deteriorates under the weight of suspicion and jealousy. In both narratives, the female figure progressively ceases to exist as an autonomous alterity to become a projection of male concerns. Thus, Angiolina and Capitu come to occupy, in the imagination of the protagonists, a position that is both fascinating and threatening.

Such dynamics evidence the inability of these characters to fully recognize female otherness. The love bond thus becomes a space for the intensification of mimetic rivalry and the destabilization of subjective perception. In this way, the affective relationships represented in the two narratives reveal deep dimensions of the protagonists' subjectivity, putting them in contact with a facet that was latent until then: jealousy.

To understand the relations between desire, rivalry and jealousy present in these works, we will resort to the theoretical contributions of René Girard, especially the notion of mimetic desire and the mechanisms of mediation of desire.

2 A LOOK AT DESIRE AND JEALOUSY

The pillars of Girard's ideology are based, above all, on his mimetic or imitative theory. For Girard, "we all always have a model that we imitate" (GIRARD, 2000, p. 85), we always choose a model to inspire us and the same happens with desire. For the French theorist, desire is also imitative, and tends to increase if there is awareness that the object of desire is desired by another. To, Girard,

Novelistic works are thus grouped into two fundamental categories – within which secondary distinctions can be infinitely multiplied. We will speak of *external mediation* when the distance is sufficient for the two spheres of *possibilities*, whose center is each occupied by the mediator and the subject, not to be in contact. We shall speak of *internal mediation* when this same distance is sufficiently reduced for the two spheres to penetrate each other with greater or lesser depth. (GIRARD, 2009, p.33)

When dealing with external mediation and internal mediation, Girard analyzes the figure of the rival, also called mediator. External mediation, according to the French philosopher, occurs when there is no contact between subject and mediator. On the other hand, in internal mediation, the distance is reduced "so that the two spheres penetrate each other with greater or lesser depth" (GIRARD, 2009, p. 33). It should be noted that it is not the physical space that determines this distance, but factors of a social, ideological, intellectual, affective, loving and/or sexual order.

For René Girard, every love relationship is structured in a triangular way, always being mediated by a third element — the rival or mediator — who interferes in the constitution of desire. In this sense, the dynamic between subject and object of desire is never direct, but crossed by the presence of this third party, which can operate both in external and internal mediation.

In both novels, the triangular relationships are widely explored and act, in a way, as a guiding thread of the narrative. In *Senility*, for example, the protagonist lets himself be involved by the seduction of Angiolina Zarri, believing he has control of the situation. His initial posture already evidences this attempt at domination, when he says: "I like you, but in my life you will never be more than a toy. I have other duties, my career, my family..." (SVEVO, 1982, p.11). However, he falls madly in love with her, or rather, with "Ange", "a creature invented by Emilio, through an artistic rewriting consciously distorted from what has been lived" (STASI, 2009, p. 89). For Ernestina Pellegrini, Angiolina, an obscure object of desire, would not only be an invention of Emilio, but an "artificial construction" that is also made with the cooperation of her sister Amalia (PELLEGRINI, 1999, p. 15). From the beginning, he idealizes his mistress, starting with the name:

The name Angiolina did not please her literary sensibilities. He called her Lina; then, this diminutive not being enough, he foisted on her the French name of *Angèle*, and often ennobled it and abbreviated it in *Ange*. (SVEVO, 1982, p.31)

Also according to Pellegrini, in *Senility an upside-down stilnovism gains space*, as the woman is more of a witch than an angel, or is even a fallen and Luciferian angel (PELLEGRINI, 1999, p.20). Angiolina, Ange, Giolona are ironic names, which refer to ambiguous and antithetical meanings, such as the purity of the angel or the malice of the devil. Ange would also be a reduction of the name Angelica, the beautiful and manipulative protagonist created by Boairdo and immortalized by Ariosto, whose name refers to carnal desire.

Parallel to the progressive transformation of the name of Angiolina, as Stasi points out, there is the process of angelization of women (STASI, 2009, p.87). Angiolina, emancipated as a woman, seductive, sensual, in Emilio's eyes will be transformed into the naïve *Ange*, who is angelic and innocent and does not really present anything, except in the chimera of the protagonist. If we take the narrative in its entirety, the excerpt below denotes irony between the narrator and the protagonist, as Emilio is aware that "his angel woman" only exists in his delusions:

(...) The woman he loved, **Ange, was his invention**, he had created her with premeditated effort; she had not collaborated in that creation, nor had she allowed herself to be made, since she had shown resistance. In daylight the dream evaporated. (SVEVO, 1982, p.55, emphasis added)

The Svevian narrative follows the protagonist's self-deceptive movement, making the figure of Angiolina appear less as an autonomous character than as an unstable projection of Emilio's consciousness. The instability of desire, therefore, does not manifest itself only at the thematic level, but crosses the protagonist's own narrative perception, continuously oscillating between idealization and disenchantment.

Angiolina, as is evident throughout the novel, remains relatively innocent in the face of the process of imaginary metamorphosis imposed on her by her lover. This process is significantly close to the dynamics present in *Dom Casmurro*. Bento Santiago also builds Capitu from a deeply subjective and idealizing look. However, as jealousy intensifies, the previously fascinating image of the protagonist begins to be crossed by suspicion and distrust, making the figure of Escobar emerge as an imaginary rival and mediator of desire.

From this perspective, Escobar can be understood as a decisive element in the configuration of the triangular structure of desire in *Dom Casmurro*, since his presence is progressively incorporated into Bento Santiago's interpretative field as a threat to the couple's affective stability. Similarly, in *Senility*, the relationship between Emilio Brentani and Angiolina is also organized based on a mediation that destabilizes the alleged autonomy of the desiring subject. In both novels, René Girard's perspective is confirmed, according to which desire is not structured directly, but always mediated by a third element, whose presence intensifies rivalry, imaginative projection and the instability of love relationships.

In the light of René Girard's mimetic theory, Bento Santiago begins to retrospectively reinterpret his relationship with Capitu under the sign of rivalry, transforming Escobar into a simultaneous mediator of his desire and his suffering. The notion of internal mediation formulated by Girard proves to be particularly productive for the reading of the novel, to the

extent that subject and rival belong to the same affective and social circle, sharing emotional closeness and constant coexistence.

In this way, both Emilio Brentani and Bento Santiago prove incapable of establishing loving relationships based on otherness and trust. Both replace the real woman with imaginary constructions produced by their own subjective concerns. The love desire then becomes a space of idealization, rivalry and psychic suffering, making jealousy emerge as the maximum expression of the identity instability of these protagonists.

The third element that makes up the love triangle is responsible for arousing different feelings in the desiring subject, such as desire, envy, love, rivalry or jealousy. The mimetic theory proposed by Girard is quite dynamic, since the model chosen to be imitated can later be the rival, or even become the desiring subject. The rival (or mediator), therefore, plays a fundamental role in the intensification of desire, since the desiring subject tends to value the love object even more when he realizes that it also arouses interest in a third element.

In *Senility*, Emilio Brentani will have his desire for Angiolina Zarri increased when he realizes that the *blonde with big blue eyes* was very desired by other men:

He looked at the photographs. An old man who had been photographed in the pose of a great gentleman, leaning on a pile of papers. Emilio smiled. "My godfather," Angiolina introduced. A young man dressed in Sunday clothes, an energetic face, bold look. "My sister's godfather," said Angiolina, "and this is my younger brother's godfather," and he showed the portrait of another young man softer and better dressed than the first.

"**Are there still others?**" asked Emilio, but the mockery died on his lips because among the photographs he had discovered two together, of **people he knew: Leardi and Sorniani!** (...)

Angiolina did not immediately understand why Emilio's forehead had become so gloomy. **For the first time, brutally, he allowed himself to be betrayed by jealousy:** "I don't like to find so many men in your room. (...)

Suddenly a great hilarity burst into her face, and she said that she **was very glad to see him jealous.** "Jealous of these people!" she said afterwards, returning to her seriousness and with an air of reproach. (SVEVO, 1982, pp.40-41, emphasis added)

Emilio's jealousy is evident, but it was decided to realize, at this moment, another key of interpretation, that is, that of desire. The protagonist, who could distance himself from his lover for promiscuous behavior, has his desire for her sharpened. According to Gabriel Andrade, in *René Girard: an intellectual portrait*, "the desiring subject needs a model that supports his decision; never dares to desire on his own" (ANDRADE, 2011, p.400). Thus, Emilio needs to know that Angiolina is desired, he needs a model to be "inspired" and consequently, desire her.

A similar dynamic occurs in *Dom Casmurro*. As Bento Santiago becomes suspicious of the relationship between Capitu and Escobar, jealousy progressively intensifies, transforming

his friend into a rival and mediator of his desire. The mere possibility that Capitu could be admired and desired by another man becomes enough to emotionally corrode the protagonist.

In *Dom Casmurro*, the progressive predominance of internal mediation is observed. The dandy episode, often pointed out as one of the first explicit manifestations of Bentinho's jealousy, can be understood, at first, as a case of external mediation. However, a more attentive reading allows us to relativize this initial interpretation, showing that the episode is not limited to the circumstantial figure of the knight, but refers to a mimetic structure still in formation, perceptible in the following excerpt:

The rider was not content with walking, but turned his head to our side, Capitu's side, and looked at Capitu, and Capitu at him; the horse walked, the man's head went backwards. Such was the second tooth of jealousy that bit me. Strictly speaking, it was natural to admire the beautiful figures; but that fellow used to pass by in the afternoons; he lived in the old Field of Acclamation, and then... and then... Go there and reason with a heart of embers, as mine was! (MACHADO DE ASSIS, 2019, p.115)

At first glance, jealousy seems to be directed at the dandy, whose presence triggers Bentinho's reaction. However, as already suggested by Helen Caldwell, the episode allows us to glimpse a more complex dynamic, in which the true core of the rivalry is not necessarily concentrated in this occasional rival. Capitu's remark — "What kind of friend is this size?" — when referring to Escobar, as well as Bento's complimentary description of his friend, indicate that the potential rivalry is already oriented in another direction (MACHADO DE ASSIS, 2019, p.113).

Even so, at this moment, mediation remains external, to the extent that Bento "is not aware that Escobar is the object of his jealousy" (CALDWELL, 2002, p.27). This confirms that the distinction between internal and external mediation does not depend only on physical proximity, but on the structural position occupied by the mediator in desire.

The social dimension of the relationship between Bento Santiago and Capitu had already been widely explored by Roberto Schwarz and Silviano Santiago, especially with regard to the possessive logic that structures the love bond. Schwarz observes that, after marriage, Bento consolidates himself as a "figure of order" (SCHWARZ, 1997, p.29), making his jealousy cease to be just imaginative instability and start operating as an exercise of authority. In the same vein, Silviano Santiago states that "to love is to marry, it is to buy property titles" (SANTIAGO, 2000, p.31), evidencing the articulation between love, possession and exclusivity in Machado's novel.

At this point, the Girardian reading allows us to advance in relation to Caldwell's interpretation. It is not only a matter of shifting the focus of jealousy from an apparent object to

a deeper one, but of making explicit the mechanism that organizes this displacement: the episode suggests that Bento's desire is never addressed to Capitu in a fully immediate way, structuring itself from an early age as dependent on a mediating instance, even if it is not fully configured. The dandy, therefore, does not constitute the effective mediator, but functions as a surface element that makes visible the structural need for mediation in the protagonist's desire.

This process becomes even more evident after Escobar's death, when Bento Santiago obsessively fixes himself on Capitu's gaze in front of his friend's corpse:

Finally, the time has come for ordering and leaving. Sancha wanted to say goodbye to her husband, and the desperation of that move dismayed everyone. Many men cried too, all the women. Only Capitu, supporting the widow, seemed to overcome herself. He consoled the other, wanted to get her out of there. The confusion was general. In the middle of it, **Capitu looked for a few moments at the corpse so fixed, so passionately fixed**, that it is not surprising that a few and silent tears came to him... (MACHADO DE ASSIS, 2019, p.173, emphasis added)

From this episode, Bento Santiago begins to retrospectively reinterpret his love trajectory under the sign of suspicion and rivalry. Escobar then becomes a mediating element of the protagonist's desire and simultaneously of suffering. In the light of René Girard's mimetic theory, it is perceived that the rival plays an essential role in the intensification of love desire and psychic suffering.

As João Cezar de Castro Rocha observes, in the introduction to *Romantic Lie and Romantic Truth*,

Love and jealousy always form an indissoluble pair: jealousy ensures the promise of the other, in the real or imaginary presence of the rival. It does not matter: jealousy assures that the object of my desire *is also desired by others*, and in the mirror of their eyes my desire can only increase. (GIRARD, 2009, p.17)

Thus, both Emilio Brentani and Bento Santiago, when they become lovingly involved, come into contact with dimensions of their subjectivities hitherto unknown. Jealousy thus emerges as an effect of the impossibility of the protagonists to sustain relationships not mediated by rivalry and imaginative projection. What initially could be just a pleasurable love experience gradually becomes suffering, obsession and identity instability.

If, at first, Emilio Brentani and Bento Santiago believe they control their love relationships, they gradually become dominated by them. The sentimental adventure ceases to be episodic and becomes the organizing center of their existences. In the novels analyzed, the love desire is not based on reciprocity, but on rivalry and constant comparison with a third element. It is

precisely at this point that René Girard's theory of mimetic desire proves to be productive, as it allows us to understand how the protagonists' desire intensifies from the mediation exercised by the rival.

In *Senility*, Emilio Brentani feels profoundly inferior in front of Stefano Balli. The sculptor represents everything that Emilio would like to be: virile, self-assured, admired by women and fully integrated into social life. Balli's own physical description evidences this symbolic superiority:

Balli, on the contrary, had made better use of his forty years well lived, and his experience made him competent to judge his friend. He was less cultured, but he had always exercised over the other a kind of paternal authority, consented, desired by Emilio, who, despite his unfortunate but absolutely threatening fate, and his life in which there was nothing unforeseen, needed support to feel safe.

Stefano Balli was a tall, strong man, with the blue eyes of a child on one of those tan-looking faces that never grow old: the only trace of age was the gray of his brown hair, his beard trimmed with precision, his whole figure very correct and somewhat hard. His observant eye was sometimes sweet when curiosity or compassion animated him, but he became very hard in the fight or in the most futile discussions. (SVEVO, 1982, p.19, emphasis added)

The rivalry is not only born of the common interest in Angiolina, but of the privileged position that Balli occupies in Emilio's imagination. The friend becomes a model and a threat simultaneously. The protagonist desires Angiolina, but also wants to possess the qualities he identifies in Balli. In this sense, the rival does not only interfere in the love relationship: he structures his own desire.

Emilio's jealousy intensifies as Balli grows closer to Angiolina. The protagonist starts to see his friend as directly responsible for his suffering:

"You're jealous of me, just imagine, **your best friend!**" roared Balli indignantly. (SVEVO, 1982, p.81, emphasis added)

"However," confessed Emilio, sincerely moved by Balli's affection, "I have never suffered so much from jealousy as I do now." Stopping in front of Stefano, he said to him in a deep voice, "Do you promise that you will tell me everything you know about her?" **I don't want you to go near her, but if you see her on the street come and tell me right away.** Promise? Does it formally promise? (SVEVO, 1982, p.128, emphasis added)

If it weren't for him, his relationship with Angiolina would have been smoother, not complicated by such bitter jealousy. (SVEVO, 1982, pp.131-132, emphasis added)

It was even firm by fate that **Balli would always intervene to make Emilio's situation more painful in the face of Angiolina.** (SVEVO, 1982, p.191, emphasis added)

The constant presence of the rival transforms love into anguish. Emilio becomes unable to work, to think about anything else or to organize his life in the slightest:

In fact, his whole life now belonged to that love; he did not know how to think of anything else, he did not know how to work, nor even to fulfill his duties of office normally. (SVEVO, 1982, p.44)

Moved, Emilio confessed. Yes. Now he saw him clearly. The thing became very serious, and he described his own love, the anxiety to see her, to speak to her, the jealousy, the doubts, the incessant anguish, and the perfect forgetfulness of all things that did not concern her or her own feeling. (SVEVO, 1982, p.57-58)

The narrative follows the progressive narrowing of Emilio's perceptive horizon, whose consciousness begins to reorganize all reality from the love obsession. Jealousy thus appears as a symptom of a fragile and dependent subjectivity. As already mentioned, Emilio explicitly recognizes the pathological character of his obsession, attributing to himself the condition of a "strange, unhealthy individual" (SVEVO, 1982, p. 106).

In this context, Angiolina should not be understood as the cause of the protagonist's suffering, but as an element that triggers tensions that already exist in his subjectivity. Emilio cannot sustain an affective relationship because his identity continuously depends on the approval, comparison, and recognition of the other.

At the end of the novel, even though he is away from Angiolina, Emilio remains imprisoned in the past. Love is transformed into an idealized memory, revealing that the experience of love did not produce maturation, but existential crystallization:

Years later he looked with a certain admiring charm at this period of his life, the most important, the most luminous. He lived like an old man with the memories of his youth. In her idle literary spirit, Angiolina underwent a strange metamorphosis. She kept her beauty unchanged, but she still acquired all the qualities of Amalia, who died in her a second time. She became sad, disconsolately inert, her gaze acquired an intellectual clarity. He saw her before him as on an altar, the embodiment of thought and pain, and he loved her always, if love is admiration and desire. She represented all that he had thought and observed in this period of nobleness.

His figure, moreover, became a symbol. He always looked at the same point on the horizon, the future from which the golden glows that reverberated on his pink, luminous and white face departed. I expected! The image fulfilled the dream he had once built with Angiolina and that the daughter of the people had not been able to understand. (SVEVO, 1982, pp.267-268)

The outcome shows that Emilio does not overcome the love experience, but re-inscribes it imaginarily in an idealized form. Memory does not restore Angiolina as an objective reality, but as a subjective construction reorganized by nostalgia and self-deception. If in *Senility* the mimetic mediation is structured above all by the rivalry between Emilio and Balli, in *Dom Casmurro* it acquires even greater complexity, becoming not only a theme, but an organizing

principle of the narrative itself. In Machado de Assis, jealousy ceases to be just a feeling experienced by the character and begins to structure the form of the story.

At first glance, jealousy seems to be directed at occasional rivals. However, as already suggested by Helen Caldwell, mimetic mediation progressively shifts to the figure of Escobar. Capitu's remark — "What friend is this size?" — when referring to his seminary colleague already indicates the symbolic centrality that he will occupy in Bento Santiago's affective economy (MACHADO DE ASSIS, 2019, p. 113).

Initially, however, this mediation still remains diffuse, as Bento does not fully recognize Escobar as a rival. Girard's theory allows us to understand precisely this movement: desire is not immediately directed to the beloved object, but is organized on the basis of a mediating instance that attributes value to it.

The consolidation of this triangular structure becomes more evident when Escobar starts to occupy a privileged position in the relationship between Bento and Capitu:

The separation did not cool us down. He was the third in the exchange of letters between me and Capitu. From the moment he saw her, she encouraged me a lot in our love. The relations he had with Sancha's father strengthened those he already had with Capitu, and made him serve both of us, as a friend. At first, it was hard for her to accept it, she preferred José Dias, but José Dias disgusted me for a remnant of childlike respect. Escobar won; although vexed, Capitu handed him the first letter, which was the mother and grandmother of the others. Not even after he was married did he suspend the favor... That he married, – guess who, – married the good Sancha, Capitu's friend, almost her sister, so much so that sometime, writing to me, he called her "his little sister-in-law". Thus, affections and kinships, adventures and books are formed. (MACHADO DE ASSIS, 2019, p.143)

The passage is decisive because it makes explicit the constitution of the love triangle. Escobar does not appear as an external element to the relationship, but as a figure who actively participates in the rapprochement between Bento and Capitu. The mediator becomes constitutive of the loving bond.

From that moment on, jealousy progressively intensifies. Benedict begins to retrospectively reinterpret the events, reorganizing his memory according to a suspicious logic. The episode of Escobar's wake marks the culmination of this process: "Capitu looked for a few moments at the corpse so fixed, so passionately fixed, that it is not surprising that a few and silent tears came to him..." (MACHADO DE ASSIS, 2019, p.173).

More than objective evidence of adultery, Capitu's gaze reveals the interpretative functioning of Bento's jealous conscience. The narrator transforms ambiguous gestures into imaginary proofs. As Roberto Schwarz observes, "there is no way to be sure of Capitu's guilt,

nor of innocence"; what exists is Bento's insistent attempt to organize the facts according to his accusatory hypothesis (SCHWARZ, 1997, p. 16).

In *Jealousy: a study on the Proustian imaginary*, Nicolas Grimaldi thoroughly analyzes the presence of jealousy in Marcel Proust's work, especially considering the role of imagination in the consciousness of the subject "victim" of this feeling. According to the author, "jealousy would thus be all the more torturous the more surrendered to the imaginary, and the imagination all the more intense and painful the more it visualized the beloved woman in an infinity of possible encounters, situations, gestures and behaviors" (GRIMALDI, 1994, p. 46). Such a reflection proves to be particularly productive for the reading of Dom Casmurro, since Bento Santiago's jealousy intensifies precisely because his conscience converts evidence into evidence, indefinitely expanding the possibilities of betrayal.

In this way, the narrator remains at the mercy of an imaginative activity that not only fills gaps, but also retrospectively reorganizes the lived experience. This perspective is close to the reading of Gilberto Pinheiro Passos, according to which the jealous person establishes a particular relationship with knowledge:

He knows more than the others. Facts and information keep an undisguised dose of gap, which it is up to him to fill. It seeks, at all times, to give the world a more complete meaning, making it reveal data for which only its feeling is ready. In this way, it lurks: **any sign can be the distinctive mark of the information that it itself engenders** (PASSOS, 2003, p. 76, emphasis added).

From this logic, it is understood that Bento Santiago's suffering does not stem from a concrete proof of adultery, but from the imaginative activity itself that transforms suspicions into subjective certainties. Benedict does not actually witness the betrayal; he produces it narratively through associations, clues, and retrospective interpretations. His memory reveals itself to be unstable, while the imagination occupies a central position in the construction of his version of the facts, subordinating memory to the logic of suspicion and transforming jealousy into the organizing principle of both his affective experience and the narrative itself:

No, no, **my memory is not good**. (...) How I envy those who have not forgotten the color of the first pants they wore! I don't like the ones I stuck yesterday. I swear only that they were not yellow because I execrate that color; But this can be forgetfulness and confusion. (MACHADO DE ASSIS, 2019, p.95-96, emphasis added)

On the other hand, imagination emerges as the dominant force:

Being alone, I reflected for some time, and **had a fantasy**. You already know my fantasies. (...) **Imagination was the companion of my entire existence** (...). **I believe I have read** in Tacitus that Iberian mares conceived by the wind; if it was not in him, it was in another ancient author, (...). In this regard, my imagination was a great Iberian mare; (MACHADO DE ASSIS, 2019, p.70-71, emphasis added)

Imagination not only complements the gaps in memory, but starts to organize the entire experience of the protagonist. As Grimaldi states, jealousy becomes more painful the more surrendered to the imaginary. Benedict continually projects possible scenes, attributes hidden meanings to gestures and converts suspicions into convictions.

This dynamic explains why not even Escobar's death dissolves the rivalry. The mediator remains acting symbolically through the figure of Ezekiel:

[Ezekiel] was neither more nor less than my old and young companion in the seminary of St. Joseph, a little shorter, less full-bodied, and, except for the colors, which were vivid, **the same face as my friend**. He was dressed in modern fashion, of course, and the manners were different, but the general appearance reproduced our dead person. **He was himself, the exact one, the real Escobar**. It was my combo; He was his father's son. (MACHADO DE ASSIS, 2019, p.194, emphasis added)

The dead rival continues to structure Bento's desire and suffering. Jealousy becomes autonomous in relation to the facts and becomes a permanent principle of interpretation of the world. It is precisely at this point that *Dom Casmurro* reaches his greatest formal complexity. The novel is not organized around the proof of adultery, but the narrative construction of jealousy. Bento Santiago does not only report events: he interprets, reorganizes and manipulates them retrospectively. Jealousy becomes, therefore, a narrative form.

The fragmentation of the chapters, the digressive character of the memories and the associative chain of the narrative formally express a consciousness marked by suspicion. The story advances less through the objective succession of facts than through the interpretative insistence of the narrator. Each episode is taken up again as a possible confirmation of a previously established hypothesis.

In this way, Machado de Assis radicalizes the problematic of mimetic desire by shifting it from the thematic plane to the structural plane of the narrative. In *Dom Casmurro*, jealousy is not only Bento Santiago's subjective experience; he organizes the very logic of the novel, determining the way in which events are narrated, selected and interpreted. The mimetic desire ceases to operate only on the level of the relationships between the characters and begins to model the very structure of the novelistic discourse.

3 FINAL CONSIDERATIONS

The comparative reading of *Senility* and *Dom Casmurro* allowed us to observe that, despite the historical and cultural differences that separate Italo Svevo and Machado de Assis, both novels construct male protagonists deeply marked by subjective instability, by amorous idealization and by the inability to sustain affective relationships based on otherness. Emilio Brentani and Bento Santiago reveal themselves to be characters who, in the face of the love experience, tend to replace the real woman with imaginary constructions produced by their own concerns, insecurities and fantasies. In this sense, Angiolina and Capitu come to exist less as fully accessible characters than as surfaces of projection of the male gaze.

From the theoretical contributions of René Girard, it became possible to understand that the love desire, in both novels, is structured in a triangular and mimetic way. Love is not immediately established between subject and desired object, but is constantly crossed by the presence of a mediator or rival, responsible for simultaneously intensifying desire, rivalry and psychic suffering. In both *Senility* and *Dom Casmurro*, jealousy emerges precisely from the protagonists' inability to deal with the autonomy of the female figure and the instability of their own perceptions.

The analysis also showed that, although the two novels present significant thematic approximations, each author develops this problem in a unique way. In Svevo, the narrative follows the continuous movement of self-deception of Emilio Brentani, whose perception oscillates between idealization and disenchantment. In Machado de Assis, on the other hand, jealousy goes beyond the thematic plane and begins to organize the narrative structure itself, making memory, suspicion and imagination central elements in the construction of the story. In *Dom Casmurro*, the fragmentation of the narrative and the instability of the memorialistic voice reveal that jealousy is not only a subjective experience of the protagonist, but the organizing principle of his perception of the world.

In this way, the novels analyzed demonstrate that love, far from representing a space of balance or full fulfillment, becomes an experience marked by rivalry, imaginative projection and identity crisis. Both Emilio Brentani and Bento Santiago remain imprisoned in their own subjective constructions, incapable of fully recognizing feminine otherness. Thus, *Senility* and *Dom Casmurro* reveal, from different perspectives, the fragility of modern subjectivities and the mechanisms by which desire, imagination and jealousy deform the experience of love and the perception of reality.

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INCLUSION AS A SOCIAL RESPONSIBILITY: THE ACCESSIBILITY CENTERS OF THE FEDERAL INSTITUTE OF RIO DE JANEIRO AND THE POLYTECHNIC INSTITUTE OF VISEU IN PORTUGAL

A INCLUSÃO COMO RESPONSABILIDADE SOCIAL: OS NÚCLEOS DE ACESSIBILIDADE DO INSTITUTO FEDERAL DO RIO DE JANEIRO E DO INSTITUTO POLITÉCNICO DE VISEU EM PORTUGAL

LA INCLUSIÓN COMO RESPONSABILIDAD SOCIAL: LOS CENTROS DE ACCESIBILIDAD DEL INSTITUTO FEDERAL DE RÍO DE JANEIRO Y DEL INSTITUTO POLITÉCNICO DE VISEU EN PORTUGAL



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ABSTRACT

This work is an excerpt from a doctoral thesis that aimed to analyze the policies in the area of Social Responsibility found in the Federal Institute of Education, Science and Technology of Rio de Janeiro (IFRJ) and the Polytechnic Institute of Viseu (IPV), regarding the inclusion of students with disabilities and specific needs. In this work, the Accessibility Centers are presented, highlighting Social Responsibility and the legal and normative advances for access to education for People with Disabilities (PwDs) and with specific needs. This study is within the scope of research with qualitative and quantitative approaches, and uses participatory research employing bibliographic research, analysis of documentary collections, and interviews as data collection instruments. The research results showed that IPV managers practice inclusion as Social Responsibility and emphasize the importance of consolidating an inclusive culture through actions and projects. The accessibility centers, despite the difficulties, have demonstrated a commitment to inclusion. Other aspects highlighted include the urgent need for changes in management attitudes so that inclusion is truly effective. We hope that the issues raised by this research will contribute to the spread of a culture of inclusion and human rights, generating a continuous and productive dialogue to promote inclusion as a Social Responsibility.

Keyword: Social Responsibility. Federal Institute of Rio de Janeiro. Polytechnic Institute of Viseu. Accessibility Centers. Inclusion.

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RESUMO

Este trabalho é um recorte de uma tese de doutorado que teve o objetivo de analisar as políticas na área de Responsabilidade Social encontradas no Instituto Federal de Educação, Ciência e Tecnologia do Rio de Janeiro (IFRJ) e no Instituto Politécnico de Viseu (IPV), sobre a inclusão dos estudantes com deficiência e necessidades específicas. Neste trabalho, os Núcleos de Acessibilidade são apresentados evidenciando a Responsabilidade Social e os avanços legais e normativos para o acesso à educação das Pessoas com Deficiência (PcD)s e com necessidades específicas. Este estudo encontra-se no âmbito das pesquisas com abordagens qualitativa e quantitativa, e utiliza a pesquisa participante empregando como instrumentos de coleta de dados, o levantamento bibliográfico, a análise de acervo documental e entrevistas. Os resultados da pesquisa mostraram que os gestores do IPV praticam a inclusão como Responsabilidade Social e enfatizam a importância da consolidação de uma cultura inclusiva por meio de ações e projetos. Os núcleos de acessibilidade, apesar das dificuldades, têm demonstrado compromisso com a inclusão. Outros aspectos ressaltados incluem a necessidade urgente de mudanças nas atitudes da gestão para que a inclusão seja verdadeiramente efetiva. Esperamos que a problematização levantada por esta pesquisa contribua para a propagação da cultura de inclusão e dos direitos humanos, gerando um diálogo contínuo e produtivo para promover a inclusão como Responsabilidade Social.

Palavras-chave: Responsabilidade Social. Instituto Federal do Rio de Janeiro. Instituto Politécnico de Viseu. Núcleos de Acessibilidade. Inclusão.

RESUMEN

Este trabajo es un extracto de una tesis doctoral que tuvo como objetivo analizar las políticas en el área de Responsabilidad Social del Instituto Federal de Educación, Ciencia y Tecnología de Río de Janeiro (IFRJ) y del Instituto Politécnico de Viseu (IPV), en relación con la inclusión de estudiantes con discapacidades y necesidades específicas. En este trabajo, se presentan los Centros de Accesibilidad, resaltando la Responsabilidad Social y los avances legales y normativos para el acceso a la educación de las personas con discapacidades y necesidades específicas. Este estudio se enmarca dentro de la investigación con enfoques cualitativos y cuantitativos, y utiliza la investigación participativa empleando investigación bibliográfica, análisis de colecciones documentales y entrevistas como instrumentos de recolección de datos. Los resultados de la investigación mostraron que los directivos del IPV practican la inclusión como Responsabilidad Social y enfatizan la importancia de consolidar una cultura inclusiva a través de acciones y proyectos. Los centros de accesibilidad, a pesar de las dificultades, han demostrado un compromiso con la inclusión. Otros aspectos resaltados incluyen la necesidad urgente de cambios en las actitudes de la dirección para que la inclusión sea verdaderamente efectiva. Esperamos que los temas planteados por esta investigación contribuyan a la difusión de una cultura de inclusión y derechos humanos, generando un diálogo continuo y productivo para promover la inclusión como Responsabilidad Social.

Palabras clave: Responsabilidad Social. Instituto Federal de Río de Janeiro. Instituto Politécnico de Viseu. Centros de Accesibilidad. Inclusión.

1 INTRODUCTION

This work is an excerpt from a doctoral thesis⁴ that aimed to analyze the policies in the area of Social Responsibility found at the Federal Institute of Education, Science and Technology of Rio de Janeiro (IFRJ) and at the Polytechnic Institute of Viseu (IPV) on the inclusion of students with disabilities and specific needs. One of the specific objectives of the research was to investigate the policies in the area of Social Responsibility found in the IFRJ and IPV, on the inclusion of students with disabilities and specific needs.

An overview of IFRJ and IPV is presented, some actions and projects of their Accessibility Centers and, in addition, we analyze normative and guiding documents of these centers. In the IFRJ documents, we analyze the Inclusive Special Education Policy (PEEI), approved in June 2023, the only internal normative document that governs Special Education at IFRJ, long awaited by the community, we can say that, in recent years, it has been one of the main aspirations of the Center for Assistance to People with Specific Educational Needs (NAPNEs).

For the reflective analysis of inclusion as Social Responsibility, we used some works collected in the bibliographic survey of the research, such as: Félix (2003), Almeida (2010), Leal *et al.* (2011), Lima (2002), among others. In addition, we are based on the "Green Paper on Social Responsibility.

Methodologically, this study adopts a mixed approach, combining qualitative and quantitative methods, through participant research and triangulation of methodologies. The triangulation is based on two main pillars: bibliographic survey, documentary analysis and detailed evaluation of the material that underlies the theoretical basis of the research. These elements cover topics such as Special Education and Professional Education in Brazil and Portugal, as well as institutions such as IFRJ and IPV. In addition, the analysis of data obtained by the e-SIC consolidates this initial stage. In the second pillar of triangulation, the analyses of the interviews carried out at the IPV stand out, which offer an essential qualitative perspective.

The research has the potential to awaken in readers a deep reflection on the important connection between Special Education and Social Responsibility. This can increase the visibility of the actions carried out by the Accessibility Centers, both at IFRJ and IPV and in the various educational institutions, including the almost seven hundred Federal Institutes throughout Brazil, and the various Polytechnic Institutes spread from north to south in Portugal. By

⁴ DIAS, Kátia Arruda. *Polytechnic Education in Brazil and Portugal: An Analysis of Social Responsibility with Special Education in IFRJ and IPV*. 2025. 260 f. Thesis (PhD in Sciences, Technologies and Inclusion) - Graduate Program in Sciences, Technologies and Inclusion, Institute of Biology, Fluminense Federal University, Niterói, 2025.

highlighting this relationship, it is hoped that the work will contribute to a greater appreciation and recognition of inclusion and accessibility initiatives, promoting a closer look at the social and educational impact of these actions.

2 THE FEDERAL INSTITUTE OF EDUCATION, SCIENCE AND TECHNOLOGY OF RIO DE JANEIRO AND THE POLYTECHNIC INSTITUTE OF VISEU

We will make a brief historical contextualization of the researched Institutions, IFRJ and IPV, scenario and *locus* of the study, based on content available on the official website of IFRJ⁵ and IPV⁶.

IFRJ had its origin with the creation of the Technical Course in Industrial Chemistry (CTQI), in the 1940s, during World War II, at a time when the area of industrial chemistry was seen as strategic for Brazil. In 1999 it became CEFETQ and, in 2001, CEFETQ began to offer undergraduate and graduate courses, in addition to high school and technical courses. On December 29, 2008, through Law No. 11,892 (Brasil, 2008a), CEFETQ was transformed into IFRJ.

The organizational structure of the Federal Institutes (IFs) is defined by Law No. 11,892 (Brasil, 2008a), which establishes the Federal Network of Professional, Scientific and Technological Education (RFEPCT), and creates the IFs. The IFs have an organizational structure, unlike basic education schools, which allows them to be compared to Federal Universities.

IFRJ is a multidisciplinary and multi-campus Institution of Basic and Higher Education, specialized in the provision of Professional and Technological Education (EPT), with operations in research, innovation and extension, enjoys university autonomy. IFRJ operates at different levels and modalities of Basic Technical and Technological Education (EBTT), from Professional Education, with extension courses, offering training in the Youth and Adult Education (EJA) modality, through Initial and Continuing Training (FIC) courses at the Elementary level, High School Level (technical courses that can be taken in an integrated, concomitant and subsequent way to High School), Higher Technology Course, Bachelor's Degree, Licentiate, Lato and Stricto Sensu Post-Graduation.

IFRJ currently has 15 *campuses* installed in the state of Rio de Janeiro, they are: Arraial do Cabo, Belford Roxo, Duque de Caxias, Engenheiro Paulo de Frontin, Mesquita, Nilópolis, Niterói, Paracambi, Pinheiral, Realengo, Resende, Rio de Janeiro, São Gonçalo, São João de

⁵ Available at: <https://portal.ifrj.edu.br/institucional/historia-ifrj>

⁶ Available at: <https://ipv.pt/>

Meriti, Volta Redonda and the Rectory. According to the Institution's portal, IFRJ was awarded three new *campuses*: Olympic Park, Teresópolis and Complexo do Alemão.

In Portugal, the public Polytechnic Higher Education network is composed of 15 Polytechnic Institutes. According to the Report (ORSIES, 2023), the IPV was created in 1979 and offers a training offer, distributed among the five schools it currently integrates, the CTeSP, undergraduate, master's and postgraduate courses in the areas of agricultural, food and veterinary sciences, education, arts, communication, sports, technology, management and health.

The School of Education of Viseu (ESEV) was the first Organic Unit of a polytechnic to start operating in Portugal. Its training offer is in the area of teacher training, its founding matrix (since 1983), but also in the areas of education and social intervention, communication, arts, sports and physical activity.

In addition to ESEV, IPV has the School of Technology and Management of Viseu (ESTGV), created in 1985, which offers undergraduate, master's and senior professional technician courses in the areas of engineering, technology and management, marketing and tourism. The Agrarian School of Viseu (ESAV) was created in 1994, training students in the areas of agronomy, animal production, food engineering, biotechnology and veterinary nursing, an activity that has proved to be an extremely important contribution to the development of the regional economy.

Created in 1999, the School of Technology and Management of Lamego (ESTGL), with its area of coverage that is tourism, management, accounting, administration, informatics, telecommunications and social work. The School of Health of Viseu (ESSV), created in 1971, has as its mission the creation and dissemination of knowledge in the areas taught, contributing, through its own means, to the promotion and development of the level of health of the populations.

In this way, the IPV assumes its vocation in the scientific, cultural, artistic and technical training of qualified professionals, in an articulation between the provision of services to the community, research and the strengthening of partnership networks with regional, national and international entities for the development of projects and activities of common interest.

3 THE IPV ACCESSIBILITY CENTER

Among the activities developed in the IPV's accessibility center, we highlight the support and monitoring of Students with Specific Educational Needs (ENEE) and awareness and information actions for students. IPV has active partnerships with institutions that support

disability and disability, involved in research projects (IncluiES+) and intervention (promotion of employability) with partner entities. Also noteworthy is the Peer-to-Peer project for inclusion, which aims to mobilize informal peer support.

The IPV Social Responsibility and Innovation Report (RIS), 2023, with regard to the IPV's NAPNE, is intended to promote equity and inclusion of ENEE, in Higher Education, for this purpose it develops to Support Students with Disabilities, assuming itself as a welcoming and inclusive public Higher Education Institution.

In addition, it evaluates and monitors ENEE in the teaching and learning and transition processes (psychopedagogical assessments and preparation of opinions, socio-educational support, preparation of guiding documents and specific support materials), promotes seminars on inclusion and (in)information/awareness actions on typology of difficulties and specific needs, promotes intervention and research projects on inclusion in HE and has sought to establish and expand the network of collaboration protocols and partnerships with partner entities to support people with disabilities and disabilities.

According to the Report (ORSIES, 2023, p.112), the IPV's NAI-ENEE directs its actions and has as references the Convention on the Rights of Persons with Disabilities and the National Strategy for the Inclusion of Persons with Disabilities, which reinforce the inalienable right of students to an inclusive education system, particularly those with specific needs.

The NAI-ENEE of the IPV is directed to the issues of equity and inclusion of ENEE, in Higher Education, and aims to: (i) Contribute to the definition and implementation of policies and practices for the inclusion of ENEE in the IPV, in particular, in the transition and support for the self-determination of students; (ii) Enhance the inclusion of ENEE in the IPV, through evaluation-intervention processes, with the proposal of learning support measures provided for in statutes and specific regulations; (iii) Promote (in)information and awareness actions on diversity and typology of specific difficulties, aimed at the academic community, promoting a culture of equity and inclusion in the IPV; (iv) Enhance the development of ENEE's personal skills and employability, promoting professional transition processes, in collaboration with partner entities; (v) promote, in collaboration with the relevant services, accessibility to buildings and information and learning systems, as well as to the institutional portals of the BTI; (vi) Create synergies with disability and disability support entities and HE institutions, in national or international projects, aimed at research and development of good practices for the inclusion of ENEE.

The measures used to achieve the objectives according to the IPV RIS are: (i) Evaluation and monitoring of ENEE in the teaching and learning and transition processes

(psychopedagogical evaluation and preparation of respective opinions; socio-educational support); (ii) Preparation of guiding documents and specific materials to support ENEE; (iii) Proposal for seminars on the inclusion of ENEE and (in)formation and awareness-raising actions on the typology of specific difficulties and needs; (iv) Establishment of collaboration protocols and partnerships with partner entities to support people with disabilities and disabilities (awareness-raising and training actions); (v) Intervention and research projects on inclusion in Higher Education.

The initiatives to monitor students are in the evaluation, monitoring and psychopedagogical support activities of ENEE. In 2022/2023, under the coordination and monitoring of NAI-ENEE, with the support of the services of the Office for Support and Promotion of Inclusion (GAPI), of the School of Education of Viseu (ESEV), 70 students with Specific Educational Needs were identified, of which 40 were at ESEV.

According to data from the NAI-ENEE Coordination, the most expressive specific need in the IPV ENEE is Specific Learning Disorder (Dyslexia, dysorthography) with 34.3%, followed by chronic disease with 21.4%, Autism Spectrum Disorder (ASD), cognitive difficulties, Hearing impairment/disability/deafness (8.6%), other condition (5.7%) and Motor Impairment/incapacity, Hyperactivity Disorder with Attention Deficit, Visual impairment/disability/blindness (4.3%).

The follow-up translates into attendances of at least 4 sessions per student, as well as additional sessions to carry out weekly or occasional follow-ups, in person and non-face-to-face.

4 THE CENTER FOR ASSISTANCE TO PEOPLE WITH SPECIFIC NEEDS OF IFRJ

NAPNE was created from the TEC NEP Program/Action, in 2000. According to the Program, each Institution of the Federal Network, according to its regulations and resolutions, should implement the NAPNE on their *campuses*, with the objective of instrumentalizing the Professional Education Network, to expand the accessibility of people in the Special Education public (Dias, 2025).

In 2011, the end of the TEC NEP Program was announced, leaving the FIs deprived of an effective proposal for inclusive actions in the RFEPCT. In this way, a gap opened, waiting for a substitute Program, which did not occur, when we concluded that, since 2011, we have been without a guide for inclusion in the Network, but the NAPNEs continued, and continue, with the possibility of inclusion of their students with disabilities and specific needs, because the NAPNE continues to represent the only action within the scope of the IFRJ, aimed at the Special Education public on *campuses* (Dias, 2025).

Even with all this, the NAPNE continues with the PNEEPEI proposal, which aims to guide pedagogical practices and ensure the school inclusion of students with disabilities, Pervasive Developmental Disorders and High Abilities/Giftedness in the regular school system (Brasil, 2008d). Thus, at IFRJ in 2014, the NAPNE Regulation was created, which continues to this day without reformulations.

When the subject is the public that the NAPNE should serve, there are always deep discussions, because, as we are dealing with inclusion, we cannot exclude, but we must think about the structure of the centers, their limitation of operation and service.

After many discussions at the IFRJ NAPNEs Forum, about the significant increase in the number of students to attend the centers, and with the conclusion of the work prepared by the Working Group (WG) created in 2021, to prepare an Inclusion Policy, in June 2023, the Inclusive Special Education Policy of the Federal Institute of Rio de Janeiro was approved, ConSup/IFRJ Resolution No. 125 (IFRJ, 2023), which had been expected for a long time by the IFRJ community, and brought a profound documentary change regarding the public to be served in the centers.

In the evaluation of Dias (2025), the preliminary discussions of the WG, the need to expand the Special Education audience was verified, due to the fact that most of the students served by the NAPNEs on the *campuses* do not fit into the target audience of Special Education, according to the legislation in force, with most of them having "specific needs" and not "disabilities".

It is important to remember that such a change may be related to the fact that the IFRJ, from its creation in 2008, until the implementation of the PEEI document (2023), has no references in its internal guiding documents to public Special Education students, and also does not mention the expressions "Special Education public" or "Special Education", not even in the NAPNE Regulation (IFRJ, 2014), even though Special Education is a teaching modality, as conceptualized by PNEEPEI (Brasil, 2008, p.15): "(...) A teaching modality that crosses all levels, stages and modalities".

The important change, with regard to the Special Education public in the PEEI, was crucial to the development of the work carried out by the NAPNEs of the IFRJ, especially for students with "specific needs" to be left out of the conceptualization of the target audience of Special Education and, it should be noted that the PEEI of the IFRJ expanded the Public of Special Education for service and support in the centers, As we can see in its first article:

At the Federal Institute of Education, Science and Technology of Rio de Janeiro (IFRJ), the target audience of Inclusive Special Education Policies is considered to be students with

disabilities, with pervasive developmental disorders, with high abilities or giftedness and/or other specific needs related to learning disorders and disorders (IFRJ, 2023, p.3).

In the same article, paragraph four, the document provides a much broader definition of "specific needs" that meets the LBI (Brasil, 2015): "[...] that related to some physical, emotional, cognitive and/or mental need characteristic of a disability and/or learning disorder or disorder, of a temporary and/or permanent nature" (IFRJ, 2023, p.3).

It seems appropriate to say that due to the expansion of the Special Education public presented in the PEEI, the NAPNEs use, to serve their students, the term "specific needs", thus expanding the public. We understand that inclusive education needs to encompass and not be exclusionary with groups that have real needs and that need modalization for learning to occur.

We can affirm that, as for the Special Education public, the PEEI of IFRJ is in tune with the historical and normative milestones and with the inclusion policies agreed upon by the Educational Development Program (PDE), the LDB (Brazil, 1996), the PNEEPEI (Brazil, 2008), the LBI (Brazil, 2015), Decree No. 6,571/2008 (Brazil, 2008), Decree No. 7,611/2011 (Brazil, 2011), the Universal Declaration of Human Rights (UN, 1948), the Federal Constitution of 1988 (Brazil, 1988), the World Declaration of Education for All (Brazil, 1990), the Salamanca Declaration (UNESCO, 1994) and the PNEE (Brazil, 1994).

In view of these considerations, the PEEI of IFRJ becomes the most important normative act for inclusion, supporting Special Education at IFRJ. Such approaches may guide the NAPNEs to the development and consolidation of joint work, aiming at improving the conditions of access, permanence and success of public students of Special Education at IFRJ and the development of continuing education for civil servants on *campuses* for this purpose.

These and other diagnoses on inclusion as a Public Policy at IFRJ are the results of research carried out in the Professional Master's Course in Diversity and Inclusion at the Fluminense Federal University, by Dias, Fernandes and Salgado⁷ (2020), and the article the Inclusive Special Education Policy of the Federal Institute of Rio de Janeiro: an analysis from the perspective of human rights⁸, by Dias, Lacerda, Salgado and Correia (2024).

5 INCLUSION AS SOCIAL RESPONSIBILITY

Social Responsibility has been a topic of research interest and is being studied in different areas of knowledge, under different approaches. In addition, Social Responsibility has

⁷<https://app.uff.br/riuff/bitstream/handle/1/30343/Disserta%C3%A7%C3%A3o%20de%20Mestrado.pdf?sequence=1&isAllowed=y>

⁸ <https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/6606>

been the subject of intense and controversial debate for the construction of its concept, in addition to commonly studied areas such as Corporate Social Responsibility, Corporate Social Responsibility, Social and Environmental Social Responsibility and Individual Social Responsibility (Dias, 2025).

After analyzing the bibliographic survey carried out in this research, we conclude that the subject of Social Responsibility has been developing more markedly in the organizational sphere and dealing with the most varied objectives, articulated and associated with various approaches, such as: leadership, governance, public policies, social and corporate performance, *stakeholder theory*, marketing, strategic management, legal responsibility and values.

In addition, it was evidenced that the theme of Social Responsibility has been achieving remarkable prominence in scientific publications at national and international level from different perspectives and that, despite being old, it is still recent and developing, with theoretical diversity and multiple interpretations, pointing to different directions of knowledge, emerging from it several multidisciplinary aspects, but without a conceptual consensus.

In view of this, we find varied definitions and a diversity of approaches to Social Responsibility, without finding an understanding and definition that is widely accepted. Thus, from the approaches found, they seem to contain an idea of voluntary social practice on the part of private companies. This practice is operationalized in different ways and with a view to benefiting varied audiences.

Based on these data, we will present in this work some concepts of Social Responsibility, found in the bibliographic survey. However, in this article, we will be based on the concept of Social Responsibility linked to⁹ the ORSIES Green Book, which is a collaborative network of Higher Education Institutions (HEIs), which fosters the social dimension of HEIs and promotes the sharing of experiences and good practices on Social Responsibility policies and practices.

The idea of Social Responsibility advanced along with the social, political and economic transformations that took place in society throughout the twentieth century. Until around the 50s, Social Responsibility was seen in companies when they supported social causes and practiced donations (Almeida, 2010). The theme gained greater visibility from the 50s onwards, being considered by Bowen (1953 *apud* Almeida, 2010), as the modern era of social responsibility.

From the 80s to the present day, according to the same author: "the concept of sustainable development becomes part of the discourse on Social Responsibility and the theory

⁹ In 2001, the European Commission, with the aim of "launching a broad debate and obtaining views on corporate social responsibility at national, European and international level" (European Commission, 2001, p. 7), published a Green Paper "Promoting a European framework for corporate social responsibility".

of *stakeholders*¹⁰ broadens the framework of the company's responsibilities in all groups that affect or are affected by business action" (Almeida, 2010, p.58). Social responsibility is attributed to the company, as a moral and ethical entity, and not to the individual who makes the decisions for it.

Thus, the relationship between ethics and Social Responsibility is recent, despite its rapid evolution. For Bowen (1957), Social Responsibility has been, since its origin, related to Christian movements, taking into account the close relationship of the latter with ethics and morals. Thus, it should not only take into account its own interests, but be concerned with its workers, its customers and the community.

Following this line of thought, Social Responsibility is a form of management based on an ethical and transparent relationship, concerned with achieving the sustainable development of society, respecting diversity and contributing to reduce social inequalities, in order to promote quality of life for human beings (Leal *et al.*, 2011). The Green Paper of the Commission of the European Communities proposes an idea of Social Responsibility that goes towards the aforementioned concept, assuming that institutions must contribute to a better, more equitable society, with a cleaner environment, understanding the good of all through behaviors that respect the values of social, environmental and economic sustainability.

Nowadays, Social Responsibility has become one of the greatest challenges of globalization. In the understanding of *Thiry-Cherques* (2003 *apud* Almeida, 2010), currently, the Social Responsibility of each individual extends to all humanity, present and future.

In contemporary times, Social Responsibility must be an integral part of management through a transparent and ethical behavior of the institution, in which the objectives become compatible with sustainable development and a driver in the reduction of social inequalities (Almeida, 2010).

The Green Paper of the Commission of the European Communities brings, in the concept of social responsibility, the construction of a fairer and more transformative society, and for this, it should be implicit on a voluntary basis. When they take a proactive stance, the repercussions felt translate into a positive social balance, encouraging responsible behavior (Almeida, 2010).

To provoke forceful reflections on Social Responsibility, both Institutions and citizens have a very relevant role in contributing to the improvement of society's conditions, through the development of Social Responsibility, whether at the level of practices, at the level of reflection, training and education of citizens' values or in research on the subject.

¹⁰ *Stakeholders* means strategic audience and describes all people or "interest groups" that are impacted by the actions of an enterprise, project, company or business.

As seen, Social Responsibility approaches are dynamic with a systemic and multidisciplinary vision. The definition of Social Responsibility has gone through approaches with biases that align various interests, from the preservation of economic value, as well as that of the collectivity.

Social Responsibility actions are attitudes that make society more dignified, commonly applied in the business sector, but should and can be applied, mainly, by individuals and companies in the most diverse branches and types. According to the Abrinq Foundation:

Social responsibility is the way of thinking and acting ethically in relationships. Despite being strongly related to companies, the practice can be directly linked to an action, carried out by individuals or legal entities, whose main objective is to contribute to a fairer society (Abrinq Foundation, 2020).

With this understanding, the company's Social Responsibility is linked to a social commitment of the legal entity, that is, it becomes responsible for factors that aim to help society as a whole, in the same way, the individual can have this same understanding.

In summary, the importance of Social Responsibility for society was evident. However, it was noticed that this behavior is not yet widely adopted by some institutions. The problems addressed by Social Responsibility are not specific issues in the world of "academia", but rather urgent, and have to do with the survival of all. It is urgent to spread the Social Responsibility of Sciences.

6 METHODOLOGY

The question that mobilized this investigation was to analyze the policies in the area of Social Responsibility for the Special Education public and students with specific needs of IFRJ and IPV.

This study is within the scope of research with qualitative and quantitative approaches, and uses participant research using as data collection instruments, bibliographic survey, analysis of documentary collection and semi-structured interviews with open questions.

The research advanced through two preliminary paths, and a third, based on data analysis. In the first path, dedicating herself to a bibliographic survey in databases, on the portal of the Brazilian Digital Library of Theses and Dissertations (BDTD), in the Theses and Dissertations Bank of the Coordination for the Improvement of Higher Education Personnel (Capes), on publications in the field of Professional Education, Social Responsibility, Special Education, and Polytechnic Education at IFRJ and IPV, which serve as a reflective basis for the elaboration of the research.

In the second path, a documentary analysis was carried out in the period from 2020 to 2024, a period after the research carried out in the master's degree. The analysis of the documentary collection aimed to know the mandatory documents that govern Professional Education and Special Education in Brazil and Portugal and their relations with the investigation, the internal normative documents of the IFRJ and the IPV, in addition to requesting information in the e-Sic system, on the Fala.BR platform to obtain updated data from the IFRJ. It is worth remembering that the answer is returned by the Fala.BR in document format, so we consider in this work, a documentary analysis.

Three types of document analysis were used in the research: (a) internal-institutional, analyzing the documents, 1. From IFRJ: ¹¹(i) the PDI and PPI (IFRJ, 2024), the 2023 Management Report (IFRJ, 2023), at the time, the last to be published on the Institutional Portal, and the PEI 2024-2028 (IFRJ 2024), and the Inclusive Special Education Policy (PEEI) of IFRJ, ConSup/IFRJ Resolution No. 125 (IFRJ, 2023); 2. From the BTI¹²: (i) Report-RIS-IPV-2022; (ii) legislation such as: laws, decrees, resolutions, ordinances, opinions and technical notes, United Nations Convention on the Rights of Persons with Disabilities (UN, 2006; ratified in Portugal, 2009); Universal Declaration of Human Rights (UN, 1948) and Convention on the Rights of Persons with Disabilities (CRPD) (2006); (iii) data collected on e-Sic.

And, the third way, through semi-structured interviews with the vice-presidency and the coordination of NAI-ENEE, IPV. As we can see in the table below (Table 1).

Table 1

Organizational structure of methodological aspects

PATHS TRAVELED	DATA COLLECTION INSTRUMENTS	METHODS
First Way	Bibliographic Survey	In databases: theses, dissertations, articles and books. Publications in the field of Professional Education, Social Responsibility, Special Education, and Polytechnic Education at IFRJ and IPV.
Second Way	Document Analysis of three types: (a) institutional internal; (b) legislation; (c) e-SiC data	Analysis of the mandatory documentary collection that governs Professional Education and Special Education in Brazil and Portugal. In addition to requesting information through the e-Sic system, to obtain updated data from the IFRJ.
Third Way	Interviews	Interviews with two IPV managers.

Source: Prepared by the authors.

¹¹ Available at: <https://portal.ifrj.edu.br/institucional/documentos-institucionais-e-norteadores>

¹² Available at: <https://www.ipv.pt/homepage/nee/>

The request for information through the web electronic system, of the Federal Executive Branch, the e-Sic system, to obtain updated data from the IFRJ, took place through the opening of a process in July 2024, in Fala.BR. After the authorization of the IPV directors and the agreement of the UFF, the research was submitted to the analysis and approval of the Research Ethics Committee¹³ via Plataforma Brasil, under the Certificate of Presentation of Ethical Appreciation No. 70572123.7.0000.8160, for the involvement of human beings.

For the qualitative treatment of the data, the content analysis proposed by Bardin (2011) was used. According to Bardin (2011), content analysis is a data processing technique that aims at the objective, systematic and quantitative description of the manifest content of communications, with the purpose of interpreting them (Minayo, 2010). In the perspective of Minayo (2011), based on Bardin (2011), this type of analysis aims to go beyond the level of common sense and subjectivism in interpretation, seeking to achieve critical vigilance in the communication of documents, literary texts, biographies, interviews or observation results.

In the author's assessment, the analysis aims to examine, categorize and classify the data in a way that makes it possible to reach the answers to the problem proposed in the investigation. In order to facilitate operationalization, these procedures were divided into three stages: "pre-analysis, exploration of the material and treatment of the results, inference and interpretation" (Bardin, 2011, p.95).

7 RESULTS

We sought to present specificities of what occurred throughout the research and the exercise of the analysis of the collected data. The apprehensions presented demonstrate the analysis of the practice of Social Responsibility adopted in the accessibility centers of IFRJ and IPV. As it is an excerpt from a thesis, the results will be abbreviated.

In this work, the result of the analysis of the documentary architecture focused particularly on the guiding institutional documents and internal regulations of IFRJ and IPV, verifying, above all, the alignment with the legislation and the proposal of Social Responsibility to ensure the access, permanence and successful completion of students with disabilities and specific needs of the researched Institutions.

Through the bibliographic survey, the analysis of the documentary collection and the semi-structured interviews with open questions, some historical and normative milestones were found that changed the course of Special Education in Portugal, such as Decree-Law No.

¹³ Available at: <http://cephumanas.sites.uff.br/>

3/2008, which defined the specialized support for the inclusion of students with special educational needs in regular schools.

In 2018, Decree-Law No. 54/2018 was published, which establishes the legal regime for inclusive education in Portugal, accompanied by Decree-Law No. 55/2018, which places Portugal in a group of countries that have legislation on inclusive education. The Decree-Law provided, in article 33, for the creation and updating of a support manual for inclusive education, aimed at schools, their professionals and parents.

The proposal of the decree was the elaboration of an inclusive curriculum in schools in Portugal, which meets and respects the specific needs of students. Knowing that the curriculum and meaningful learning are the soul of a school, Decree No. 54/2018 brings with it guidelines for recognizing the diversity of students, discovering the various ways of dealing with their peculiarities, adjusting the teaching processes and making the learning of these students increasingly meaningful, adapting them to the individual characteristics and conditions of each one. In this way, Decree No. 54/2018 brought significant contributions to Inclusive Special Education in Portugal.

The PDI has become the most important document in the IFs, as it contains all the Institution's data, such as: objectives, goals, institutional programs for the qualification of civil servants, institutional evaluation, institutional planning for teaching, research and extension, campus infrastructure, the promotion plan for social inclusion and diversity. These are the references that allow us to identify and reflect on how Special Education has been considered in the daily practice of this Institution.

In the IFRJ documents analyzed, the institution does not bring in its mission, vision and values, inclusion as a social responsibility. As a vision, the PDI presents: *"To be a reference in professional, scientific, technological and cultural education, in a humane, inclusive, diverse and plural way, integrating innovative teaching, research and extension actions in line with the demands of society and the transformation of life"* (IFRJ, 2024, emphasis added). The IFRJ Portal, on the other hand, informs as an institutional vision: *"To be an Institution recognized by society as a reference in professional, scientific and technological education at different levels and modalities of education"* (IFRJ, 2024, emphasis added).

Regarding the vision, IFRJ is categorical in stating that it is a reference institution. It is worth remembering that, since 2018, we have been researching how inclusion happens on *IFRJ campuses*, one of the results is the lack of infrastructure, both financial, material and human resources in the NAPNEs (Dias, 2025). It should be highlighted, within the scope of the

research developed here, that diversity and inclusion are fundamental for the constitution of a teaching of reference and excellence.

Values are principles, customs, and ideas that guide people's behavior, attitudes, and decisions in the exercise of their responsibilities and attributions. As values, the PDI presents: *"Ethics; Equity and Social Justice; Valuing People; Diversity and Inclusion; Excellence and Quality; Integration; and Social, Environmental and Economic Responsibility"* (IFRJ, 2024, emphasis added). Regarding values, we found an advance, as the terms "Diversity and Inclusion" and "Social Responsibility" were included, the latter, even if linked to organizational, institutional, environmental and economic sustainability.

The PEI has 15 strategic objectives, and was prepared concomitantly with the PDI, both effective from 2024-2028. The Strategic Plan allowed the construction of the strategic map. It presents, in addition to the mission, vision and values, the 15 strategic objectives defined for the 2024-2028 cycle. The goal "Internal Processes P2" states: "Implement inclusive programs, projects and actions with a view to equity and social justice", we realize that inclusive actions are included, we just don't know how to carry out inclusive actions, without a minimum infrastructure in the centers, without Specialized Educational Service, without Multifunctional Resource Rooms (SRMs), without translators and interpreters of Libras, without qualified professionals to work with the Special Education public, which is only increasing every semester, and the number of students enrolled with specific needs exceeds that of students with disabilities, such facts were results in the aforementioned 2020 survey (Dias, 2025) and are confirmed here.

Another internal normative document analyzed was the General Regulation, approved by Resolution No. 16 of the IFRJ Superior Council on August 10, 2011 (Brasil, 2011), and the Statute (IFRJ, 2009), both of which are outdated and, to date, unchanged.

At IFRJ, ConSup Resolution No. 55 of December 17, 2014 (Brazil, 2014) creates the NAPNE Regulation (IFRJ, 2014). A simplistic regulation, which deals with the competences, composition, mandate, administrative organization and functioning, attributions and infrastructure, although anachronistically, remains in force. It is important to highlight that in the Statute (IFRJ, 2009), in the General Regulations (IFRJ, 2011), in the NAPNE Regulation (IFRJ, 2014), the terms "Special Education public", "Special Education", "Inclusive Education" and "Inclusion" are not mentioned at any time. Even though Special Education is a teaching modality, as well as Professional Education. Another unusual highlight is that, in the NAPNE Regulation, citations from documents referring to Special Education, such as PNEEPEI, are used, but the text of the document does not deal with its audience.

History repeats itself in the documents analyzed, in which, in the 2020 survey (Dias; Fernandes; Salgado, 2020), the unusual is verified, as the mandatory documents, of greater importance of the IFRJ, have not yet been able to define the Special Education public in their Institution. The interaction of this compilation of elements makes it possible to verify that, since the 2020 survey (Dias; Fernandes; Salgado, 2020) to date, four years later, the documents that have been modified by virtue of being quadrennial, have had advances in their texts.

In the current IFRJ documents, the term "Special Education public" was used once in the PDI, and was not used in the other documents. The term "Special Education" was used nine times in the PDI, twice in the PPI, six times in the Management Report and seven times in the Strategic Plan. The term "Inclusive Education" was applied thirteen times in the PDI, seven in the PPI, twice in the Report and 1 in the Plan. The expression "Specialized Educational Service" was used once in the PDI, once in the PPI and twice in the Report. The "Multifunctional Resource Room" is mentioned once in the PDI and in the Report. In this way, we verify, even if at a very slow pace, the situation has been changing.

Another document analyzed was the IFRJ's Inclusive Special Education Policy. In the IFs, it is extremely important for the consolidation of inclusive processes, an institutional policy where access is planned, from the conditions for participation in the selection process, with translation of the notice into Libras and Braille, the presence of TILs and mediators in the tests, aiming at the permanence and successful completion of the course at the Institution.

Contributing to broaden the discussions about the creation of the Inclusive Special Education Policy (IFRJ, 2023), we can say that it is one of the main aspirations, in recent years, of the NAPNEs, having been approved in June 2023. In addition to the creation of the policy itself, one of the greatest advances materialized in practice was the expansion of the EE target audience, with regard to students with "specific needs", which are left out of the conceptualization of the EE target audience, which we have in the national legal documents.

It is believed that if an inclusion policy contemplates these points, it fulfills its role as a driver of inclusive actions and practices, leading the Institution to the longed-for culture of inclusion, so that students will have their rights guaranteed as proclaimed in the Universal Declaration of Human Rights (UN, 1948), which emphasizes equal rights and opportunities for all people, regardless of their capabilities. In this sense, the declaration emphasizes the importance of equal opportunities, individual autonomy and full participation in society.

The information collected in the e-Sic and in the interviews, with regard to the analysis of the structures of the NAPNEs and NAI-ENEE, their potentialities and limitations in the services and the social responsibility with students with specific needs, indicate that the IPV

accessibility center carries out interventions in the pedagogical work, involving the entire institution: courses, coordinations, students, families and teachers. These actions aim to promote a more inclusive and integrated education, with the active participation of all those involved in the process (Dias, 2025).

The IFRJ accessibility centers, on the other hand, have positively impacted the teaching-learning process, for students with disabilities and specific needs, seeking solutions to the most varied daily problems, even with infrastructure limitations. The NAPNEs are, so far, the only initiative aimed at the EE public on *campuses*, contributing to ensure not only access, but also the permanence of these students, promoting an inclusive education, although still in a limited way.

In the area of Social Responsibility, the research revealed the protagonism of the accessibility centers that play the role of operationalizing teaching actions both for students in general and for those in Special Education. Social Responsibility is closely linked to the fulfillment of human rights, especially in the context of Special Education and, even with advances, inclusive practice still faces challenges, including the naturalization of the violation of the human rights of these people.

As for the structures of the accessibility centers, both at IFRJ and IPV, the situation points to the urgent need for investments that transform these centers into adequate and fundamental spaces within the institution, ensuring that they become centers of excellence and reference also in the inclusion of students.

In the Accessibility Center, NAI-ENEE, develops projects in inclusion, such as mentoring, integration and practical inclusion, support for athletes with disabilities. These projects aim to promote the full development of students by offering individualized support and opportunities for social and academic integration.

These IPV actions seek not only inclusion in the academic environment, but also the creation of conditions for students to develop in an integral way, both in the educational and social aspects. Another important focus of the IPV is the development of the culture of inclusion. To this end, one of the activities developed by its Center is to carry out reflection and awareness activities with students, promoting discussions on inclusion and awareness.

The work confirmed, through the participants' narratives, that the IPV managers highlighted inclusion as a Social Responsibility and emphasized the importance of consolidating an inclusive culture through actions and projects. The work of NAI-ENEE and GAPI stands out for anticipating the needs of students, offering guidance and advice to both coordinators and teachers, in addition to supporting the development of essential skills. Pedagogical initiatives,

focused on the employability and autonomy of students, are fundamental for the academic success of students, as well as the expansion of awareness-raising actions, especially among first-year students. Continuous support for students is considered crucial to ensure their permanence and success throughout their academic career. These actions reflect an institutional commitment to inclusion and equity, promoting a more accessible environment that is favorable to the full development of all students.

The performance of the NAI-ENEE, in this context, is seen as a clear example of this social responsibility. When management and the accessibility center are "anchored on the same ground", it means that there is an integration between institutional policy and the Institution's inclusive practices. This alignment is essential for the effectiveness of inclusion actions, as the strategies and decisions made by the institution's management are supported by the real needs of students, while NAI-ENEE acts as a bridge, ensuring that policies are translated into concrete actions.

8 CONCLUSION

Considering the architecture and convergence of the documents analyzed and the theme of the research, it was sought to apprehend how these documents direct the discussions about Social Responsibility in its accessibility centers and for the Special Education public, which every day shows an accelerated growth in the number of enrollments with considerable delineations and dimensions in terms of service in the accessibility centers of IFRJ.

It is possible to clearly identify the work developed within the scope of the practices of the NAI-ENEE accessibility centers in the IPV and the NAPNE in the IFRJ, highlighting their efforts to promote inclusion. At IPV, close collaboration between management and NAI-ENEE is crucial to ensure that inclusive actions remain effective and sustainable, contributing to the success of the inclusive education model.

In the narratives of the managers, it is clear that the management of the IPV is committed to respecting diversity and promoting social equity. By adopting an inclusive stance and valuing differences, the institution contributes directly to reducing social inequalities, creating opportunities for all students. This commitment to diversity promotes a quality of life for students by providing a more accessible and fair educational environment.

It is understood that there is still a long way to go so that inclusion in IFRJ is completely aligned with existing legal normative documents and internal regulations, created and not complied with by IFRJ. The current reality requires a real commitment from the institution, which needs to recognize inclusion as a genuine Social Responsibility.

Despite the challenges, it is essential that the institution begins to implement the necessary changes in order to transform the inclusion policy, still on paper, into concrete actions that positively impact the lives of students and the entire academic community. We hope that the problematization raised by this research will contribute to the propagation of the culture of inclusion and human rights, generating a continuous and productive dialogue to promote inclusion as a Social Responsibility of IFRJ.

It is concluded that this work can be an important tool for the advancement of inclusive policies and practices within the IFs educational institutions, highlighting the role of accessibility centers as essential pillars for a truly accessible and egalitarian education.

By highlighting the interconnections between Special Education and Social Responsibility, the work offers a deep reflection on the importance of inclusion in the educational context. The focus on the Accessibility Centers shows that these structures should not be seen only as support units, but as central elements for the transformation of the educational environment, promoting a space of equity, welcoming, and equal opportunities for all students, especially those with disabilities and specific needs.

It is essential that society and educational institutions recognize the role of these centers as protagonists in building a more inclusive environment, where all students have the same chances for development and academic success. With the advancement of accessibility and inclusion practices, it becomes possible to strengthen the inclusive culture within the educational environment, not only as a matter of compliance with legislation and regulations, but as a real and continuous commitment to the Social Responsibility of educational institutions.

These points serve as guidelines to promote real and meaningful inclusion, which goes beyond a simple legal adequacy and incorporates Social Responsibility effectively, ensuring that all students, regardless of their conditions, can have a successful and egalitarian educational path.

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COGNITIVE DEVELOPMENT ASSESSMENT IN PEDIATRIC PATIENTS WITH ACUTE LYMPHOID LEUKEMIA: A LONGITUDINAL STUDY IN MANAUS, AMAZONAS

AVALIAÇÃO DO DESENVOLVIMENTO COGNITIVO EM PACIENTES PEDIÁTRICOS COM LEUCEMIA LINFÓIDE AGUDA: UM ESTUDO LONGITUDINAL EM MANAUS, AMAZONAS

EVALUACIÓN DEL DESARROLLO COGNITIVO EN PACIENTES PEDIÁTRICOS CON LEUCEMIA LINFOIDE AGUDA: UN ESTUDIO LONGITUDINAL EN MANAUS, AMAZONAS



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ABSTRACT

Pediatric cancer represents one of the leading causes of morbidity and mortality in childhood, with particular emphasis on Acute Lymphoblastic Leukemia (ALL), the most common malignant neoplasm in this age group. Although therapeutic advances have raised survival rates to approximately 90%, prolonged exposure to chemotherapy during critical phases of neurological development raises important questions about its effects on children's cognitive functioning. This study aimed to assess the cognitive development of children with ALL throughout chemotherapy treatment, analyzing the Full Scale Intelligence Quotient (FSIQ) and the indices of verbal comprehension, perceptual organization, working memory, and processing speed. This is a prospective longitudinal study conducted with six pediatric participants treated at the HEMOAM Foundation in Manaus, Amazonas, between 2021 and 2022, using the Wechsler Intelligence Scale for Children — fourth edition (WISC-IV) at three assessment time points (D0, D35, and D84). Results indicated that the FSIQ remained predominantly within the average range, with transient fluctuations associated with the most intensive phases of treatment, particularly in the Processing Speed Index. The findings reinforce the importance of continuous neuropsychological monitoring throughout pediatric oncological treatment.

Keywords: Acute Lymphoblastic Leukemia. Cognitive Development. Neuropsychological Assessment.

RESUMO

O câncer pediátrico representa uma das principais causas de morbimortalidade na infância, com destaque para a Leucemia Linfóide Aguda (LLA), neoplasia maligna mais frequente nessa

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faixa etária. Embora os avanços terapêuticos tenham elevado as taxas de sobrevivência para cerca de 90%, a exposição prolongada à quimioterapia durante fases críticas do desenvolvimento neurológico levanta questões sobre seus efeitos sobre o funcionamento cognitivo infantil. O presente estudo teve como objetivo avaliar o desenvolvimento cognitivo de crianças com LLA ao longo do tratamento quimioterápico, analisando o Quociente de Inteligência Total (QIT) e os índices de compreensão verbal, organização perceptual, memória operacional e velocidade de processamento. Trata-se de um estudo prospectivo longitudinal, realizado com seis participantes pediátricos atendidos na Fundação HEMOAM, em Manaus, Amazonas, entre 2021 e 2022, utilizando a Escala de Inteligência Wechsler para Crianças — quarta edição (WISC-IV) em três momentos avaliativos (D0, D35 e D84). Os resultados indicaram que o QIT se manteve predominantemente na faixa média, com oscilações transitórias associadas às fases mais intensas do tratamento, especialmente no Índice de Velocidade de Processamento. Os achados reforçam a importância do acompanhamento neuropsicológico contínuo durante o tratamento oncológico pediátrico.

Palavras-chave: Leucemia Linfóide Aguda. Desenvolvimento Cognitivo. Avaliação Neuropsicológica.

RESUMEN

El cáncer pediátrico representa una de las principales causas de morbilidad en la infancia, con especial relevancia para la Leucemia linfóide Aguda (LLA), la neoplasia maligna más frecuente en este grupo etario. Aunque los avances terapéuticos han elevado las tasas de supervivencia a aproximadamente el 90%, la exposición prolongada a la quimioterapia durante fases críticas del desarrollo neurológico plantea interrogantes sobre sus efectos en el funcionamiento cognitivo infantil. El presente estudio tuvo como objetivo evaluar el desarrollo cognitivo de niños con LLA a lo largo del tratamiento quimioterápico, analizando el Cociente de Inteligencia Total (CIT) y los índices de comprensión verbal, organización perceptual, memoria operacional y velocidad de procesamiento. Se trata de un estudio prospectivo longitudinal, realizado con seis participantes pediátricos atendidos en la Fundación HEMOAM, en Manaus, Amazonas, entre 2021 y 2022, utilizando la Escala de Inteligencia Wechsler para Niños — cuarta edición (WISC-IV) en tres momentos de evaluación (D0, D35 y D84). Los resultados indicaron que el CIT se mantuvo predominantemente en el rango promedio, con oscilaciones transitorias asociadas a las fases más intensas del tratamiento, especialmente en el Índice de Velocidad de Procesamiento. Los hallazgos refuerzan la importancia del seguimiento neuropsicológico continuo durante el tratamiento oncológico pediátrico.

Palabras clave: Leucemia Linfóide Aguda. Desarrollo Cognitivo. Evaluación Neuropsicológica.

1 INTRODUCTION

Cancer is a disease characterized by the disordered and uncontrolled growth of abnormal cells, which can invade adjacent tissues and spread to other regions of the body, compromising the functioning of vital organs and systems (National Cancer Institute, 2023). In childhood, the most frequent types of cancer differ from those observed in adults: while in adults, solid tumors originating in organs such as the breast, lung, and colon predominate, in children, hematological neoplasms predominate, diseases that affect the blood and lymphatic system, especially leukemias, which represent the most common oncological group in the pediatric age group (National Cancer Institute, 2008).

Among leukemias, Acute Lymphoblastic Leukemia (ALL) is the most frequent form in childhood. It is a malignant neoplasm, that is, a type of cancer, originating in the bone marrow, the structure responsible for the production of blood cells. In ALL, immature lymphocytes multiply uncontrollably and accumulate in the bone marrow, preventing the proper production of healthy blood cells and can spread to organs such as the thymus, lymph nodes, and central nervous system (Juliussen & Hough, 2016; Hoffbrand, 2018). This systemic involvement explains the diversity of clinical symptoms of the disease, anemia, fatigue, recurrent infections, bleeding and bone pain, and the complexity of its treatment. The disease predominantly affects children between 2 and 5 years of age, with a slight prevalence in males, and represents about 40% of pediatric cancer cases in Brazil (Soares, 2019; National Cancer Institute, 2008). In the Amazon region, a retrospective study carried out at the Hospital Foundation of Hematology and Hemotherapy of Amazonas (HEMOAM) identified 577 diagnoses of ALL between 2005 and 2015, with a predominance in males and a higher incidence in children from zero to ten years of age, evidencing the epidemiological relevance of the disease in the state context (Silva et al., 2019).

In the last four decades, the development of increasingly effective chemotherapy protocols has significantly transformed the prognosis of ALL. Until the 1970s, the disease was considered practically fatal; currently, modern chemotherapy protocols, such as the one adopted by the Brazilian Group for the Treatment of Childhood Leukemia (GBTLI), allow approximately 90% of patients to achieve complete remission (Hoffbrand, 2018). The treatment lasts about two years and is organized in sequential phases, with greater intensity in the initial stages: induction of remission, which comprises the first 35 days (D0 to D35) and aims to quickly eliminate leukemia cells, and consolidation, evaluated on the eighty-fourth day (D84), aimed at eliminating residual cells and preventing relapses. Although survival rates have increased considerably, prolonged exposure to chemotherapeutic agents during a critical period of infant

neurological development raises important questions about the effects of treatment on cognitive functions (Kingma et al., 2002).

Longitudinal studies indicate that children who survived ALL may have variable cognitive deficits, with greater impairment in those undergoing protocols that combine cranial irradiation and methotrexate (MTX), compared to those treated exclusively with chemotherapy (Roman; Sperduto, 1995; Kingma et al., 2002). This difference is explained by the synergistic effect between cranial radiation and MTX on brain tissue: both act in a neurotoxic way and, when combined, potentiate damage to neural structures involved in higher cognitive functions, such as memory, attention, and processing speed. Even in isolated chemotherapy treatments, changes in these functions have been reported throughout clinical follow-up (Insel et al., 2017). Specific investigations indicate that ALL survivors present academic difficulties more frequently, especially in mathematical reasoning, with characteristics similar to those of Specific Learning Disorder (Kaemingk et al., 2004). In the Brazilian context, a study carried out in the State of Amazonas identified global developmental delay in children hospitalized with ALL, including deficits in language and motor skills, expanding the understanding of the impacts beyond the strict cognitive domain (Fernandes, 2020).

Despite the clinical relevance of this evidence, the scientific literature still has important gaps regarding the longitudinal assessment of cognitive development during chemotherapy treatment, especially in Brazilian and regional contexts. A review carried out in the PubMed, SciELO and VHL databases, using the descriptors "acute lymphoblastic leukemia", "cognition" and "children", revealed that most of the available studies focus on populations of survivors evaluated after the end of treatment, with few records on the cognitive variations that occur throughout the different therapeutic phases (Kingma et al., 2002; Insel et al., 2017). In addition, factors such as socioeconomic status, family support, access to schooling during hospitalization, and regional characteristics can modulate the effects of treatment on neurodevelopment, as pointed out by Fernandes (2020) and Insel et al. (2017), and are still little explored in the national literature.

In view of this scenario, systematic neuropsychological evaluation during pediatric cancer treatment becomes an essential strategy for the early identification of cognitive alterations and the planning of interventions that promote the development and quality of life of these children. The Wechsler Intelligence Scale for Children, fourth edition (WISC-IV) is currently considered the gold standard psychometric instrument for children's cognitive assessment, widely recognized in the international scientific and clinical literature for its psychometric robustness and ability to accurately measure the Total Intelligence Quotient (IQ)

and indices verbal comprehension, perceptual organization, working memory, and processing speed, enabling a comprehensive and longitudinal analysis of cognitive functioning (Wechsler, 2013). This article is derived from a master's dissertation developed in the Graduate Program in Applied Sciences to Hematology at the University of the State of Amazonas (PPGH/UEA), in partnership with HEMOAM, a reference institution in oncohematological care in the North Region. The general objective of this study is to evaluate the cognitive development of pediatric patients with ALL during chemotherapy treatment. As specific objectives, we sought: to analyze the Total Intelligence Quotient (IQ) during different phases of treatment; to compare cognitive performance over time through longitudinal assessment; and to investigate changes in the indices of verbal comprehension, working memory, perceptual organization and processing speed.

2 THEORETICAL FRAMEWORK

To support the proposed investigation, this study presents a theoretical review organized into four thematic axes. The first addresses Acute Lymphoblastic Leukemia (ALL), with emphasis on its epidemiological, clinical and therapeutic aspects. The second discusses child neurodevelopment, considering the main cognitive functions involved in learning and the disorders associated with deficits in this process. The third axis examines the impacts of cancer treatment on cognition, based on national and international evidence. Finally, the fourth axis deals with neuropsychological assessment in a hospital context, highlighting the instruments used to monitor cognitive functioning in children with cancer.

2.1 ACUTE LYMPHOID LEUKEMIA

Acute leukemia is a group of malignant neoplasms, in other words, they are cancers originating in the hematopoietic system characterized by the uncontrolled proliferation of immature cells in the bone marrow. This process compromises the normal production of blood components (red blood cells, leukocytes and platelets) and the body's immune response, and can be fatal when not treated properly (Juliussen & Hough, 2015). These diseases have a higher incidence in childhood and can be classified according to the cell line affected into four major groups: Acute Lymphoblastic Leukemia (ALL), Chronic Lymphoblastic Leukemia (CLL), Acute Myeloid Leukemia (AML) and Chronic Myeloid Leukemia (CML) (Juliussen; Hough, 2015).

Among acute leukemias, ALL, the focus of the present study, is defined by the clonal accumulation of immature lymphocytes in the bone marrow, with possible impairment of

structures such as the thymus, lymph nodes, and central nervous system (Hoffbrand, 2018). It is the most malignant neoplasm it is frequent in childhood, predominantly affecting children between 2 and 5 years of age, with a slight prevalence in males. Its etiology is multifactorial, involving interactions between genetic and environmental factors, ionizing radiation, and spontaneous or acquired somatic mutations; about 10% of cases are associated with heredity (Alves et al., 2021).

From a clinical point of view, ALL is manifested by anemia, fatigue, fever, bleeding, petechiae, headache, lymph node enlargement, bone pain, and possible involvement of the central nervous system (Soares, 2019; Hoffbrand, 2018). The diagnosis is established based on a set of complementary procedures: the morphological and cytochemical analysis of the cells allows the identification of the type and degree of cell differentiation; immunophenotyping characterizes cell surface markers, defining the lineage involved (B or T); cytogenetics identifies chromosomal abnormalities relevant to prognosis; and cerebrospinal fluid analysis evaluates the impairment of the central nervous system (Soares, 2019; Hoffbrand, 2018).

The current classification adopted by the World Health Organization (WHO), updated in 2016, subdivides ALL according to the cell line involved, B cells or T cells, and the genetic abnormalities identified, including hypodiploidy, hyperdiploidy, and specific chromosomal translocations, such as the Philadelphia chromosome (BCR-ABL1) (Arber et al., 2016). In the present study, children with ALL lineages B and T were evaluated, since both forms make up the profile of the population treated at the investigated institution, and it is important to consider the possible prognostic and therapeutic differences between these subclassifications.

In Brazil, ALL represents the ninth most common neoplasm overall, corresponding to about 40% of pediatric cancer cases, with an estimated 5,920 new cases in boys and 4,890 in girls for the 2020–2022 biennium (National Cancer Institute, 2008). In the northern region, a retrospective study carried out at the HEMOAM Foundation identified 577 ALL diagnoses between 2005 and 2015, with a predominance in males and a higher incidence in children aged zero to ten years, with a better prognosis in this age group compared to adolescents (Silva et al., 2019).

The treatment of ALL is predominantly based on chemotherapy, with the aim of achieving complete remission of blasts in the bone marrow. The protocol of the Brazilian Group for the Treatment of Childhood Leukemia (GBTLI) organizes treatment in sequential phases, starting with the induction of remission, evaluated on days D15 and D35, followed by consolidation, with evaluation at week 12 (D84) after diagnosis. About 90% of patients achieve remission, although there is a risk of relapse associated with the presence of measurable residual disease (MRD)

(Hoffbrand, 2018). Complementary therapies, such as radiotherapy, targeted therapies, and bone marrow transplantation, may be indicated according to clinical evolution, with a total duration of treatment of approximately two years (Soares, 2019).

2.2 CHILD NEURODEVELOPMENT

Children's cognitive development comprises a set of mental processes that are progressively organized and complexified throughout childhood and adolescence, including functions such as attention, memory, language, reasoning, perception, and information processing speed (Rotta et al., 2016). These functions are interdependent and support the child's ability to learn, adapt to the environment, and develop academic and social skills. Brain plasticity, the nervous system's ability to reorganize its connections in response to experiences and stimuli, is particularly intense in childhood, making this period both a window of opportunity for development and a phase of greater vulnerability to adverse factors (Rotta et al., 2016).

Working memory, responsible for the temporary storage and manipulation of information during the performance of cognitive tasks, plays a central role in school learning, especially in reading, writing, and mathematical reasoning. Attention and concentration are fundamental executive functions for engagement in academic activities and for the regulation of behavior in structured contexts. Language, both in its receptive and expressive dimensions, underpins the development of conceptual thinking and social communication (Barkley, 2020). Logical reasoning, in turn, allows the child to establish causal relationships and solve problems of increasing complexity, while perception, especially visual and auditory perception, organizes the stimuli of the environment into meaningful representations. The speed of information processing, finally, reflects the efficiency with which the nervous system performs basic cognitive operations, being a sensitive indicator of neurological maturation (Rotta et al., 2016). Deficits in any of these functions can have a direct impact on school performance and the child's overall development.

When such deficits persist or are accentuated throughout development, they can favor the emergence of neurodevelopmental disorders, evidencing the close relationship between cognitive functions and children's mental health. Neurodevelopmental disorders are a group of conditions that begin in the developmental period, typically manifesting before school entry, with deficits that lead to impairments in personal, social, or academic functioning (American Psychiatric Association, 2022). This group includes: Intellectual Development Disorder, Communication Disorders, Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), Specific Learning Disorder and Motor Disorders. It is estimated that

approximately 7% of children at 5 years of age have impairments in language development, evidencing the significant prevalence of these conditions in the child population (O'Hare & Bremner, 2016).

In the pediatric oncological context, the occurrence of cognitive deficits can be configured both as a direct consequence of the neurotoxic effects of the treatment and as a result of the global impact of the illness on the child's development, including school withdrawal, prolonged hospitalization, emotional distress, and restrictions on learning experiences (Fernandes, 2020). Understanding child neurodevelopment in its entirety is, therefore, essential for the evaluation and follow-up of children with ALL, allowing early identification and planning of interventions that minimize the impacts of illness on cognitive development.

2.3 IMPACTS OF CANCER TREATMENT ON COGNITION

The effects of chemotherapy treatment on children's cognitive development constitute a field of research in increasing expansion. In recent decades, the number of studies dedicated to this topic has increased significantly, following the advancement of therapeutic protocols and the improvement in the survival rates of children with ALL, which has made the late effects of treatment a priority clinical concern (Kingma et al., 2002; Roman & Sperduto, 1995).

Two classic longitudinal studies, developed by the University of Maastricht, in the Netherlands, are fundamental references in this field. The first, conducted between 1978 and 1984, evaluated the psychological effects on learning of 28 children surviving ALL treated with cranial irradiation and methotrexate (MTX) (Kingma et al., 2002). The second, conducted with 17 surviving children treated exclusively with chemotherapy between 1984 and 1988, made it possible to compare the effects of the two therapeutic modalities (Roman & Sperduto, 1995).

The results of these studies confirmed that patients treated with chemotherapy alone had lower levels of learning when compared to a control group of healthy children, but with superior performance compared to those submitted to cranial irradiation associated with MTX, a group that demonstrated greater cognitive impairment and more pronounced learning deficits (Kingma et al., 2002; Roman & Sperduto, 1995). These findings indicate that although chemotherapy alone is less neurotoxic than more aggressive protocols, its effects on cognitive development should not be overlooked, especially when treatment occurs during critical phases of neurological development.

More recent research reinforces this perspective. Insel et al. (2017) identified declines in cognitive processes, especially verbal working memory, over the course of chemotherapy treatment in children with ALL, with an association between these declines and later academic

performance. Fu et al. (2017) demonstrated that variables such as gender, age at diagnosis, and chemotherapy dose may be associated with neurocognitive impairment at in patients with ALL. A study conducted at the Chicago School of Medicine found that ALL survivors had more frequent academic difficulties in areas involving mathematics, with characteristics similar to the diagnostic criteria of Specific Learning Disorder (Kaemingk et al., 2004).

In the Brazilian context, a study conducted in the State of Amazonas in 2020, also at HEMOAM, identified global developmental delay in pediatric children hospitalized with ALL, with emphasis on deficits in language and motor skills, showing that the impacts of illness go beyond the strict cognitive domain and encompass multiple dimensions of child development (Fernandes, 2020). These findings reinforce the need for a broader and interdisciplinary look at the development of these children, considering not only the direct effects of chemotherapy, but also the set of factors associated with the hospitalization and treatment process.

In view of this scenario, the importance of systematic neuropsychological follow-up throughout the treatment and in the post-therapeutic period is highlighted, as a strategy for early identification of cognitive alterations and planning interventions that minimize losses and promote better conditions for development and quality of life in this population (Rotta et al., 2016).

2.4 NEUROPSYCHOLOGICAL ASSESSMENT IN A HOSPITAL CONTEXT

Psychological assessment is a fundamental tool for the investigation of cognitive and emotional development, especially in the pediatric context, where playful strategies and caregivers' reports are often incorporated into the assessment process (Hutz, 2016). In the field of neuropsychology, the use of standardized instruments allows the identification of possible alterations in cognitive functioning, contributing to the differential diagnosis, clinical follow-up, and the planning of therapeutic and educational interventions.

Among the instruments widely used for children's cognitive assessment, the Wechsler Intelligence Scale for Children, fourth edition (WISC-IV), considered the gold standard in the measurement of the Total Intelligence Quotient (IQ) and specific cognitive indices, stands out. The instrument is applicable to children and adolescents aged between 6 and 16 years (Wechsler, 2013). It consists of fifteen subtests distributed in four factor indexes: the Verbal Comprehension Index (LCI), which evaluates reasoning, comprehension and verbal conceptualization; the Perceptual Organization Index (POI), which measures visual perception, simultaneous processing and visuomotor coordination; the Working Memory Index (IMO), which investigates attention, concentration and working memory; and the Processing Speed Index

(PVI), which assesses mental agility and graphomotor processing (Wechsler, 2013). The application of the WISC-IV is indicated in psychoeducational, clinical, and neuropsychological contexts, contributing to the diagnosis of neurodevelopmental disorders, giftedness, intellectual disability, and other conditions that affect cognitive functioning.

Table 1

Indices and subtests of the Wechsler Intelligence Scale for Children (WISC-IV)

Table of Contents	Subtests	Skills assessed
Verbal Comprehension (LCI)		
	Similarities	Verbal reasoning and abstract concept formation
	Vocabulary	Word knowledge and concept formation
	Comprehension	Verbal knowledge and ability to express yourself
Perceptual Organization (IOP)		
	Cubes	Visual perception, organization and motor coordination
	Figurative Concepts	Level of abstraction and reasoning ability
	Matrix Reasoning	Abstract reasoning and visual processing
Working Memory (IMO)		
	Digits	Memory, attention, Auditory Processing and Coding
	Sequence of Numbers and Letters	Sequencing, mental agility, memory, and attention
	Arithmetic	Mental agility, concentration, attention and memory
Processing Speed (IVP)		
	Code	Speed, memory, learning, and visual perception
	Search Symbol	Memory and visual/motor coordination, flexibility and concentration

Note. LCI = Verbal Comprehension Index; IOP = Perceptual Organization Index; IMO = Working Memory Index; IVP = Processing Speed Index.

In the pediatric oncology context, the use of standardized neuropsychological instruments becomes even more relevant in view of the potential impacts of treatment on development. The longitudinal application of WISC-IV throughout the different phases of chemotherapy treatment enables continuous monitoring of cognitive functions, allowing the identification of intra-individual variations that could go unnoticed in punctual evaluations (Martínez-Triana et al., 2013).

Despite advances in the area, the literature still has gaps regarding the longitudinal assessment of cognitive development during chemotherapy treatment, especially in Brazilian and regional contexts. In this sense, studies that systematically monitor the cognitive functioning of children with ALL throughout the therapeutic phases contribute to the expansion of knowledge about neurodevelopment in this population and for the strengthening of more integrated and humanized clinical practices.

3 METHODOLOGY

The methodology of an article outlines the procedures employed to conduct the research, including the type of study, sample selection, methods of data collection and analysis, ethical considerations, and limitations of the study. Its detailed and transparent description is essential to ensure the replicability and reliability of the results, in addition to providing a solid basis for the interpretation and generalization of the findings.

This is a prospective longitudinal study, carried out with pediatric patients diagnosed with Acute Lymphoblastic Leukemia (ALL), treated at the Hospital Foundation of Hematology and Hemotherapy of Amazonas (HEMOAM), a reference unit in oncohematology in the Northern Region of Brazil. The longitudinal design allowed the monitoring of the cognitive development of the participants throughout different phases of chemotherapy treatment, enabling the analysis of intra-individual variations over time.

As for sampling, it was carried out by convenience, consisting of spontaneous demand from pediatric patients with ALL treated at the HEMOAM Foundation from June 2021 to July 2022. Newly diagnosed patients with ALL, literate, aged between 6 and 16 years, of both sexes, were included.

The following non-inclusion criteria were adopted: previous history of psychological counseling; previously established psychiatric diagnosis; history of developmental deficit prior to the diagnosis of ALL; and motor or visual impairment that made the application of the instruments unfeasible. Participants who died during the evaluation period or who chose to withdraw from participation during the follow-up period were excluded from the study.

During the collection period, which coincided with the COVID-19 pandemic, 30 patients were admitted, of which 12 met the eligibility criteria. Of this total, 6 were included in the final sample, 5 were excluded due to impairments resulting from the disease and difficulties in adhering to treatment, and 1 died during the follow-up period.

The Sociodemographic Questionnaire and the Wechsler Intelligence Scale for Children - fourth edition (WISC-IV) were used as instruments for data collection. The Sociodemographic

Questionnaire is an instrument for collecting data on the patient's life history, covering socioeconomic, cultural, family and clinical aspects, including gender, age, education, place of birth, family income, health conditions and history of the current disease. The Wechsler Intelligence Scale for Children fourth edition (WISC-IV) is a psychometric instrument gold standard for individual cognitive assessment of children and adolescents between 6 and 16 years of age. Composed of fifteen subtests, ten main and five supplementary, the instrument measures the Total Intelligence Quotient (QIT) and four factor indexes: Verbal Comprehension Index (LCI), which evaluates reasoning, comprehension and verbal conceptualization; Perceptual Organization Index (POI), which measures visual perception, simultaneous processing, and visuomotor coordination; Working Memory Index (IMO), which investigates attention, concentration, and working memory; and Processing Speed Index (PVI), which evaluates mental agility and graphomotor processing. The application occurs individually and lasts approximately two hours, and can be divided into two sessions according to the patient's demand (Wechsler, 2013).

Data collection occurred at three different times, according to the therapeutic protocol adopted by the psychological team: Day 0, Day 2 and 3, Day 35 and Day 84. On Day 0 (D0), corresponding to the beginning of treatment, the following were performed: the application of the Sociodemographic Questionnaire with the parents and/or guardians; the presentation and signature of the Informed Consent Form (ICF) by the legal guardians; and, for adolescents, the presentation of the Illustrated Free and Informed Consent Form (TALE). On Days 2 and 3 (D~2 and D~3), the first application of WISC-IV was performed, conducted individually with the child or adolescent, during the hospitalization period to induce remission.

On Day 35 (D35), corresponding to the period after the remission induction phase, the second application of the WISC-IV was performed, with the objective of assessing the participant's cognitive development throughout the treatment. On Day 84 (D84), corresponding to the consolidation phase of the remission, the third and final application of the WISC-IV was performed; and the application of the Children's Hospitalization Deck, with the objective of investigating the emotional and behavioral state of the participant throughout the hospitalization process. Cases that, throughout the evaluations, presented indications of the need for individualized clinical follow-up were referred for routine care in the Psychology sector of the HEMOAM Foundation.

The collected data were analyzed using descriptive statistics, which summarize the central characteristics and variability of the participants' cognitive performance. To correct the WISC-IV, the raw scores obtained in each subtest were transformed into weighted scores, using

the tables by age group available in the instrument's technical manual. The weighted scores were added to calculate the Total Intelligence Quotient (IQ) and the four factor indices (ICV, IOP, IMO and PVI). The scores obtained in the three assessments (D0, D35 and D84) were compared longitudinally, allowing the analysis of variations in the cognitive performance of each participant throughout the treatment.

The study was approved by the Research Ethics Committee (REC) of the Hospital Foundation of Hematology and Hemotherapy of Amazonas (HEMOAM), under opinion number 4,632,733 and CAEE 44844521.1.0000.0009, following the ethical principles established by Resolution 466/12 of the National Health Council, which regulates research carried out with human beings. Participation was voluntary, with the possibility of withdrawing at any time without prejudice to treatment. The identity of the participants was kept confidential at all stages of the research.

4 RESULTS AND DISCUSSIONS

The following results present the characterization of the sample and the analysis of the cognitive performance of the participants throughout the three evaluation moments, considering the Total Intelligence Quotient and their respective factor indexes. Data exposure was performed using descriptive statistics, seeking to highlight patterns, variations, and trends observed throughout the longitudinal follow-up. Despite the variations identified, inferential analyses were not performed due to the small sample size.

The initial sample consisted of 12 participants; However, due to one death and the exclusion of five children due to clinical complications and low adherence to treatment, the final sample consisted of six participants. The children were aged between 7 and 10 years, predominantly male, all diagnosed with Acute Lymphoblastic Leukemia and undergoing chemotherapy follow-up in different phases of treatment.

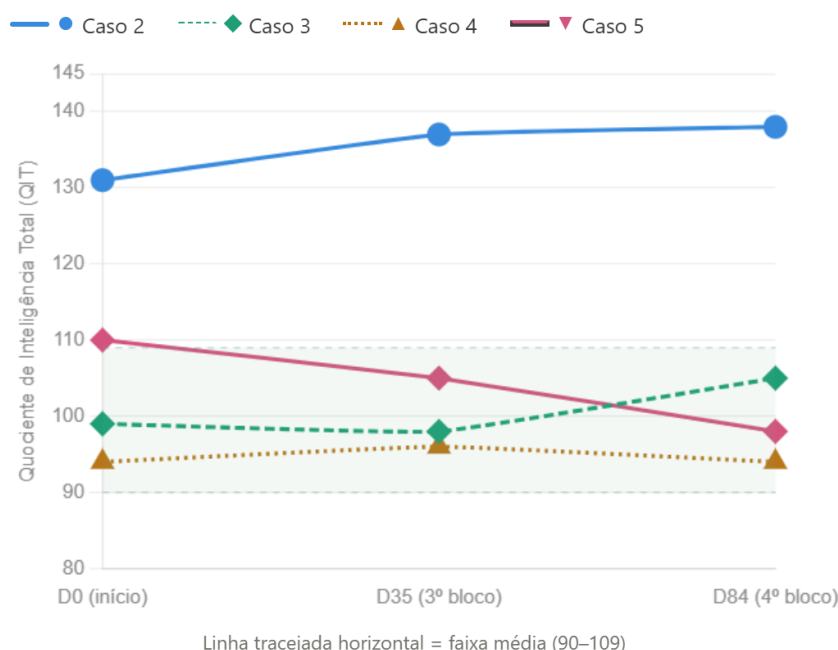
The cognitive assessment was performed longitudinally at three different moments: beginning of treatment (D0), intermediate phase (D35 – corresponding to the third chemotherapy block) and later phase (D84 – fourth block). This structure allowed us to observe not only the punctual cognitive performance, but above all its variations throughout the treatment.

The analysis of the Total Intelligence Quotient (ITQ) showed that most participants maintained their performance within the average range (90–109), although with oscillations throughout the assessments. A recurrent pattern identified in the longitudinal graphs was the

presence of a drop in performance in the second assessment (D35), followed, in some cases, by partial or total recovery in the third assessment (D84).

Figure 1

Longitudinal trajectory of the Total Intelligence Quotient (IQ) at the three evaluation moments (D0, D35 and D84) per participant



Note. D0 = start of treatment; D35 = third chemotherapy block; D84 = fourth chemotherapy block. The shaded band represents the average rating (IQ 90-109).

For example, in case 3, the IQ showed a slight decline between the first (99) and the second assessment (98), followed by an increase in the third (105), indicating a recovery that even exceeds the initial performance. Similarly, case 4 showed a slight increase in the second assessment (94 → 96), later returning to the initial level (94), configuring global stability with intermediate variation.

In contrast, case 5 showed a pattern of progressive decline (110 → 105 → 98), suggesting a greater cumulative impact of treatment on cognitive functioning. On the other hand, case 2 stood out for a consistently high performance, with an upward trajectory (131 → 137 → 138), remaining in the "much higher" rating range throughout the follow-up.

Overall, the QIT charts indicate that there is no single linear trend, but rather differentiated patterns: stability, post-fall recovery, continued growth, and progressive decline. Still, the most frequent trend suggests transient impacts associated with the most intense phases of chemotherapy.

The analysis of the WISC-IV factor indices allowed us to identify with greater precision which cognitive functions were more sensitive to variations throughout the treatment. The first index is the Verbal Comprehension Index (LCI).

The LCI showed relative stability in most cases, with performance predominantly in the middle or upper middle range. In some participants, improvement was observed over time, as in case 2, which evolved from a higher level to a much higher level. In other cases, such as case 4, there was maintenance with a slight increase only in the final evaluation. In general, the LCI was less susceptible to abrupt fluctuations.

The second, Perceptual Organization Index (POI), showed moderate variations, with a tendency to stability around the mean. However, some cases showed more marked oscillations, especially in the second evaluation. In case 3, for example, there was an increase in performance from the first to the second evaluation, followed by a new increase in the third. In case 5, on the other hand, a progressive decline was observed, following the pattern of IQ.

The third, Operating Memory Index (IMO), the working memory showed a more unstable behavior. In some cases, such as case 3, there was a decline in the second evaluation, followed by partial recovery. In case 4, the BMI started at an upper average level and showed a decrease throughout the evaluations, reaching average levels in the third application. This pattern suggests greater sensitivity of working memory to clinical conditions and treatment wear.

The fourth and last, Processing Speed Index (PVI), was the one that presented the greatest variability and the highest number of lower performances. In several cases, a sharp decrease was observed in the second evaluation, as in case 3 (86 → 68), followed by a significant recovery in the third (103). In case 4, the index also showed a strong intermediate drop, with a subsequent increase. This behavior, visible in the graphs, indicates that the processing speed is particularly vulnerable to the most intense phases of treatment, but also has potential for recovery.

An integrated reading of the results of this study allows us to identify recurrent patterns. The first is the transitory effect of chemotherapy, where, from the second assessment (D35) onwards, the main drops in performance were concentrated, suggesting a direct impact of the more intense phases of treatment on specific cognitive functions. The second pattern is subsequent recovery, since, in a significant part of the cases, the third evaluation (D84) indicated total or partial recovery, especially in indices such as processing speed and working memory.

The third pattern is the heterogeneity of cognitive profiles. The participants presented different trajectories, showing that the effects of the treatment are not uniform. While some

demonstrated cognitive resilience, others showed greater vulnerability. In addition, the preservation of global functioning was achieved, since despite the oscillations, the IQ remained, in most cases, within the mean range, indicating the absence of severe global cognitive impairment throughout the analyzed period. Finally, differential sensitivity between cognitive functions, such as processing speed and working memory, were more susceptible to variations, while verbal comprehension showed greater stability.

The results show that chemotherapy treatment is associated with cognitive oscillations over time, especially at times of greater therapeutic intensity. Such oscillations do not, in most cases, constitute a permanent cognitive decline, but rather dynamic and, to a large extent, reversible variations.

The longitudinal analysis allows us to understand the cognitive functioning of these children not as a fixed state, but as a process in flux, crossed by clinical, physical and contextual conditions. In this sense, the data reinforce the importance of continuous psychological follow-up, capable of capturing these variations and guiding interventions that are more sensitive to the temporalities of treatment.

The results obtained through the WISC-IV indicate a global cognitive functioning characterized by relative stability associated with oscillations throughout chemotherapy treatment. The Total Intelligence Quotient (ITQ) remained predominantly in the middle range (90–109), suggesting preservation of global intellectual functioning. However, a decrease was observed in the second evaluation (D35), corresponding to the beginning of the third chemotherapy block, indicating a possible impact of the more intense phases of treatment. This nonlinear pattern, with intermediate decline and subsequent recovery in some cases, suggests that the cognitive effects of treatment are dynamic and potentially reversible, influenced by clinical and contextual factors.

Among the factor indexes, the Processing Speed Index (PVI) was the most sensitive to variations, presenting greater instability. The results indicate fragility in skills related to mental agility, attention and visual-motor coordination, essential functions for processes such as reading, writing and learning. This finding points to greater vulnerability of cognitive functions that require speed and simultaneous processing of information.

In the other indices: Verbal Comprehension (LCI), Perceptual Organization (POI) and Working Memory (IMO), there was a predominance of performance in the mean, with more homogeneous variations. Even so, working memory showed oscillations in some cases, suggesting an impact on functions such as attention and information manipulation in the short term.

The individual analysis showed heterogeneity in the cognitive trajectories, with cases of stability, recovery and decline. The presence of a participant with a much higher performance stands out, contrasting with others who are more vulnerable, which reinforces the influence of individual factors, such as clinical conditions, sociocultural context and previous cognitive repertoire.

In relation to the literature, the findings partially diverge from studies that indicate significant impairments in verbal skills, since, in this study, the LCI remained mostly at the average. On the other hand, the results converge with evidence indicating that greater impairment in functions such as processing speed and working memory, especially during more intense phases of treatment.

In addition, studies suggest that variables such as age and therapeutic intensity influence cognitive performance. The data presented here corroborate this perspective by showing a greater impact in the intermediate phase of treatment, as well as oscillations in working memory. Thus, although chemotherapy is essential for disease remission, its effects can have repercussions on cognitive functioning, especially on specific functions. Still, the presence of recovery in later evaluations points to the role of neuroplasticity as a protective factor.

Finally, the need for continuous monitoring and early interventions is highlighted, aiming to minimize possible damage and favor cognitive development. The scarcity of longitudinal studies in the Brazilian context is also highlighted, indicating the importance of further research in the area.

5 CONCLUSION

The findings of this study highlight the relevance of psychological follow-up in the pediatric hospital context, especially during chemotherapy treatment, a period marked by significant physical, cognitive, and adaptive demands. Although the participants' overall cognitive performance was mostly within the average, oscillations in specific functions were identified, indicating the importance of continuous monitoring throughout the treatment.

In this sense, the potential of interventions based on playful and occupational activities as support strategies is highlighted, not only for coping with hospitalization, but also as resources that favor cognitive stimulation and psychological well-being. Play, as a structuring practice in child development, is a relevant tool in the promotion of new forms of engagement, interaction and adaptation to the hospital context.

Another central aspect refers to the continuity of the school bond, understood as a fundamental space for cognitive stimulation, socialization and development. The maintenance

of educational practices during treatment can contribute to the preservation of cognitive skills and the construction of new learning, minimizing possible impacts resulting from the withdrawal from the school routine.

Regarding the instruments used, the application of the WISC-IV proved to be relevant for the identification of possible alterations in cognitive functioning. However, its use has limitations, especially with regard to the participants' need for literacy, a factor that partially restricted its applicability in the investigated sample.

Although the literature points to possible cognitive impairments associated with chemotherapy treatment, there are still gaps in the prediction of long-term effects, especially in pediatric populations. Thus, the results presented here reinforce the need for longitudinal investigations that deepen the understanding of these alterations.

The findings of this study point to a promising direction of future research. Considering that processing speed and working memory were the most sensitive cognitive functions in the most intense phases of chemotherapy, a relevant question arises: could children who underwent these treatment protocols present, in adulthood, persistent cognitive deficits? Long-term longitudinal studies would be essential to investigate whether adult survivors of ALL in childhood manifest attentional difficulties, learning difficulties or other cognitive dysfunctions resulting from the cumulative effects of chemotherapy treatment on the developing central nervous system. This is an important scientific gap, especially in the Brazilian context, where research that follows these individuals from childhood to adulthood is still scarce.

Finally, it is emphasized that this study, as it is a convenience and exploratory sample, does not intend to exhaust the theme, but to contribute to the advancement of discussions about the integration between cancer care and mental health. Thus, it is pointed out the importance of developing interdisciplinary practices, such as music therapy, art therapy and playful interventions, which can be incorporated into the treatment, with a view to promoting the quality of life and integral development of children in an oncological context.

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USE OF INTERFERENTIAL CURRENT IN CONSTIPATED WOMEN

USO DA CORRENTE INTERFERENCIAL EM MULHERES CONSTIPADAS

USO DE CORRIENTE INTERFERENCIAL EN MUJERES CON ESTREÑIMIENTO



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ABSTRACT

Introduction: Constipation is a common problem in the general population around the world, Pelvic physiotherapy is of great importance in the treatment of pelvic floor dysfunctions and in the case of intestinal constipation, it is believed that the addition of electrical stimulation using interferential current in the treatment may improve colonic transit, facilitating the elimination of feces.

Objective: To analyze the effectiveness of interferential current for the treatment of constipation in women.

Methods: Study quasi-experimental, descriptive and cross-sectional study. The following questionnaires were used: sociodemographic; Constipational Scoring System; Bristol Stool Scale and Perceived Change Scale (PME).

Results: The sample is made up of women aged between 18 and 27 years and single. With 16,7% showed a change in score on the Bristol scale, changing from Type 2 - (Constipation) for Type 4- (Healthy Stools). Regarding the Constipation Scoring System scale, it was observed that the patients did not show relevant statistical improvement. A small reduction was seen on the constipation scale of 10 ± 3 . an improvement was observed in aspects such as mood, ability to withstand difficult situations, sleep, leisure activities and self-esteem in 83.35% of patients, an aspect that directly impacts quality of life.

Final Considerations: In view of the above, it is observed that there was a small improvement in the ROME IV criteria, the Bristol stool scale and the Perceived Change Scale, however, the use of interferential current appears to be effective for the treatment of intestinal constipation. However, due to the small sample number, it was not possible to find statistical variables.

Keyword: Interferential Current. Intestinal Constipation. Women.

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RESUMO

Introdução: A constipação intestinal constitui um problema frequente na população geral de todo o mundo, a fisioterapia pélvica tem grande importância no tratamento das disfunções do assoalho pélvico e no caso da constipação intestinal, acredita-se que a adição da estimulação elétrica utilizando a corrente interferencial no tratamento poderá melhorar o trânsito colônico, facilitando a eliminação das fezes.

Objetivo: Analisar a eficácia da corrente interferencial para o tratamento da constipação em mulheres.

Métodos: Estudo quase experimental, descritivo e de corte transversal. Foram utilizados os questionários: sociodemográfico; Constipacional Scoring System; Escala de fezes de Bristol e Escala de Mudança percebida (EMP).

Resultados: A amostra é composta por mulheres tendo entre 18 e 27 anos e solteiras. Tendo 16,7% apresentado mudança de pontuação na escala de Bristol se modificando de Tipo 2- (Constipação) para Tipo 4- (Fezes saudáveis). Com relação a escala Constipation Scoring System observou-se que as pacientes não apresentaram melhora estatística relevante. Sendo vista pequena redução na escala de constipação de 10 ± 3 , foi observado melhora em aspectos como humor, capacidade de suportar situações difíceis, sono, atividades de lazer e autoestima em 83,35% das pacientes, aspecto que impacta diretamente na qualidade de vida.

Considerações Finais: Diante do exposto, observa-se que houve pequena melhora nos critérios de ROMA IV, na escala de fezes de Bristol e na Escala de Mudança Percebida, portanto, o uso da corrente interferencial parece ser eficaz para o tratamento da constipação intestinal. Porém, devido ao pequeno número amostral não foi possível encontrar variáveis estatísticas.

Palavras-chave: Corrente Interferencial. Constipação Intestinal. Mulheres.

RESUMEN

Introducción: El estreñimiento es un problema común en la población general en todo el mundo. La fisioterapia pélvica es de gran importancia en el tratamiento de las disfunciones del suelo pélvico y, en el caso del estreñimiento intestinal, se cree que la adición de estimulación eléctrica mediante corriente interferencial en el tratamiento puede mejorar el tránsito colónico, facilitando la eliminación de las heces.

Objetivo: Analizar la efectividad de la corriente interferencial para el tratamiento del estreñimiento en mujeres.

Métodos: Estudio cuasiexperimental, descriptivo y transversal. Se utilizaron los siguientes cuestionarios: sociodemográfico; Sistema de Puntuación de Estreñimiento; Escala de Heces de Bristol y Escala de Cambio Percibido (PME).

Resultados: La muestra está compuesta por mujeres de entre 18 y 27 años y solteras. Con un 16,7% mostró un cambio en la puntuación en la escala de Bristol, pasando del Tipo 2 (Estreñimiento) al Tipo 4 (Heces Saludables). Con respecto a la escala del Sistema de Puntuación de Estreñimiento, se observó que las pacientes no mostraron una mejora estadísticamente relevante. Se observó una pequeña reducción en la escala de estreñimiento de 10 ± 3 . Se observó una mejoría en aspectos como el estado de ánimo, la capacidad para

afrontar situaciones difíciles, el sueño, las actividades de ocio y la autoestima en el 83,35% de los pacientes, un aspecto que impacta directamente en la calidad de vida.

Consideraciones finales: En vista de lo anterior, se observa que hubo una pequeña mejoría en los criterios ROME IV, la escala de heces de Bristol y la Escala de Cambio Percibido; sin embargo, el uso de corriente interferencial parece ser eficaz para el tratamiento del estreñimiento intestinal. No obstante, debido al pequeño tamaño de la muestra, no fue posible encontrar variables estadísticas.

Palabras clave: Corrente Interferencial. Estreñimiento Intestinal. Mujeres.

1 INTRODUCTION

Intestinal constipation is a frequent problem in the general population around the world, affecting both sexes and all age groups, being more frequent in women (Bharucha; Lacy, 2020). It is a symptomatology and not a specific pathology; however, it may indicate some manifestation of disease that requires investigation for its diagnosis and is characterized by difficulty in eliminating feces (Ortega *et al*, 2022).

It can generate discomfort and other disorders related to the patient's social, economic and psychological life (Bharucha, 2007). In most cases, constipation does not have its cause related to an anatomical disorder of the intestinal tract, the most common cause being the difficult passage of the fecal bolus on its way towards the anal canal. In this case, it is called primary constipation, caused by a food intake low in vegetable fiber and insufficient fluid intake (Silva *et al*, 2020).

Other factors may be associated with primary constipation, such as a sedentary lifestyle, psychological aspects such as anxiety, depression, the habit of postponing going to the bathroom, common in some work areas, and the side effects of some medications, contributing to alteration or worsening of intestinal functioning (Dias *et al*, 2023).

According to the pathophysiology, constipation can be divided into 3 categories: 1. Normal transit constipation, also called functional, is the most common form of presentation. Although the time for stool to pass through the colon is normal, the patient reports constipation, complaining of hardened stools or dissatisfaction with bowel movements. 2. Slow transit constipation that occurs due to alteration in the propulsion of feces through peristalsis 3. dysfunction of the evacuatory act or dyssynergic evacuation, which is an abdominopelvic incoordination, most commonly occurring in women who have infrequent evacuation, which can be up to once a week, commonly starting at puberty and having a wide variety of treatments including physiotherapy Sadler *et al*, 2022) (Pannemans *et al*, 2020).

Pelvic physiotherapy is of great importance in the treatment of pelvic floor dysfunctions and in the case of intestinal constipation, its therapeutic objective is to restore the function of the pelvic floor and abdominal muscles, stimulate the proprioception of the muscles, providing a contraction and relaxation in a coordinated and functional way, thus enabling a better function and quality of life for patients (Firmino, 2015). In this sense, this area of physical therapy, in relation to the approach to patients with intestinal constipation, still lacks studies, especially regarding the use of electrotherapy within the therapeutic conduct (Heemskerk *et al*, 2024) (Norton *et al*, 2023).

Interferential current (IC) is a transcutaneous nerve stimulation of medium-frequency alternating electrical currents with their amplitude modulated at low frequency for therapeutic purposes (Rampazo *et al*, 2023). In this context, it is believed that the addition of electrical stimulation using interferential current in the treatment may improve colonic transit, facilitating the elimination of feces through stimulation of the vagal sympathetic and parasympathetic nerves of the intestine. This therapy can bring beneficial effects in the sense of reestablishing good abdominopelvic coordination and thus positively interfering with the main characteristics of dyssynergic-type constipation (Samhan, 2020). In view of the above, the present study aimed to verify the efficacy of the use of interferential current in constipated women.

2 MATERIALS AND METHOD

The present study is linked to the Catholic University of Pernambuco (UNICAP), the School of Health and Life Sciences and the Physical Therapy course at UNICAP. It is an integral part of the research project entitled "Physiotherapeutic approaches in Anorectal Dysfunctions in Adults and the Elderly" under the coordination of SILVANA MARIA MACEDO UCHÔA, approved by the ethics and research committee in human beings, with the opinion number 3.049.749 and CAAE: 03239318.1.000.5206 and belonging to the Evidence-based Physiotherapy group being developed at the Corpore Sano Physiotherapy and Occupational Therapy Laboratory.

This is a quasi-experimental, descriptive and cross-sectional study, being carried out through questionnaires applied to volunteers with intestinal constipation. The sample consisted of 6 individuals. The data collection period took place from September 2023 to June 2024.

The inclusion criteria will be considered: adults in the age group of 18 to 40 years; have good cognitive function and are constipated according to the Rome IV criteria and the following exclusion criteria: Pregnant women; individuals who had gastrointestinal tract neoplasia; individuals with psychiatric disorders and individuals who are using laxative medication.

After reading and signing the Informed Consent Form (ICF), which contains clear and detailed information and the objectives of the research, the volunteers answered the following instruments: Sociodemographic questionnaire, containing questions about name, color, race, marital status, education, etc. The clinical diagnosis of constipation was based on the ROMA IV criteria for functional bowel disorders, which include the following items: fewer than three weekly bowel movements, evacuatory effort, sensation of incomplete evacuation, presence of hardened or fragmented stools, and need for manual maneuvers to facilitate bowel movements. Individuals who present at least two or more of these manifestations in at least 25% of bowel

movements in the last three months, starting at least six months before, were considered constipated (Drossman, 2016).

In addition, the Agachan questionnaire was used, consisting of questions related to bowel frequency, evacuatory effort, sensation of incomplete evacuation, abdominal pain, time to evacuate, evacuatory aid, attempts to evacuate within 24 hours, and how long it has been with constipation (Froehner *et al*, 2023). The Bristol Stool Scale was also used, which aims to identify the type of stool, and is composed of seven types: type I (small hard fragments), type II (sausage-shaped, but with lumps), type III (sausage-shaped, but with cracks on the surface), type IV (sausage-shaped, but soft and soft), type V (soft pieces, but sharp contours), type VI (pasty pieces with an ill-defined shape) and type VII (liquid, without pieces) (Martinez, 2012). Ending with a questionnaire of perceived change where it was evaluated in relation to different aspects of the patient's life such as: physical health, mood, ability to fulfill obligations, among others, being distributed into: worse than before, no change and better than before (Flag *et al*, 2011).

An IBRAMED electrostimulator with 4 channels was used, with the electrodes being placed in the regions, two abdominal (placed below the costal margin) and two paravertebral (placed between T9 and L2), producing two sinusoidal currents crossing the body and being previously greased with aqueous gel. The parameters used were as follows: 4 kHz, a beat frequency of 80-160 Hz and an intensity of at least 33 mA for 20 minutes (Chase *et al*, 2005). 10 treatment sessions were performed, once a week. Guidance was also given about the food component and its importance, and then the previously mentioned questionnaires were reapplied.

3 RESULTS

The present study would initially consist of 10 university students, however, over period 4 they gave up due to unavailability of time to continue the treatment, the study was composed of 6 university students aged between 18 and 27 years who were evaluated for the presence of constipation and appearance of feces, using the interferential current over 10 sessions, once a week. Regarding sociodemographic characteristics, it was observed that 50% (n=3) of the university students were aged between 23 and 27 years, 100% (n=6) were single and 100% (n=6) studied at a Higher Education Institution (HEI).

Table 1

Distribution of women according to sociodemographic characteristics

Sociodemographic characteristics	N	%
Age group		
18 to 22	3	50
23 to 27	3	50
Social class		
A (+15 SM)	0	0
B (5 to 15 MW)	2	33,3
C (3 to 5 MW)	2	33,3
D (1 to 3 MW)	1	16,7
E (up to 1 MW)	1	16,7
Marital status		
Single	100	6
Married	0	0

Source: Prepared by the authors.

Regarding the distribution of the university students regarding the questionnaire of constipation symptoms based on the criteria of Rome IV, the prevalence of two symptoms stands out: Defecatory effort in more than 25% of bowel movements 66.7% (n=4) and granulated or lumpy feces 66.7% (n=2). In addition, 50% (n=3) reported a decrease in the criteria for Rome IV.

It is noteworthy that, regarding the Bristol stool scale, it was found that the participants presented: Type 1 - Separate pieces hard like peanuts of 33.3% (n=2), Type 2 - Sausage shape but segmented 33.3% (n=2) and Type 3 - Sausage shapes with cracks on the surface: 33.3% (n=2). After reassessment, it was observed that 16.6% (n=1) had their scale modified, changing from Type 2 - constipational feces to Type 4 healthy feces.

Table 2

Distribution of women according to the Bristol scale

Bristol Scale	N before/after	% after
1 - Separate pieces hard as peanuts	2-1	16,7%
2- Sausage shape but segmented	2-2	33,3%
3- Sausage shapes with slits on the surface	2-2	-
4- Forms of sausage or snake smooth or soft	0-1	33,3%
5- Soft bits, but sharp outlines	-	-
6- Aerated bits, frayed contours	-	-
7- Aqueous without solid parts	-	-

Source: Prepared by the authors.

Regarding the *Constipation Scoring System*, after treatment, an increase in bowel frequency was reported by 83.3% (n=5) of the volunteers, a decrease in the frequency of

abdominal pain reported by 66.7% (n=4) and a decrease in the number of reports of situations with failures or failures to evacuate in the last 24 hours by 50%, as shown in Table 3.

Table 3

Distribution of women according to the Constipation Scoring System

Constipation Scoring System	N	% after
Frequency of bowel movements		
1-2 times every 1-2 days	2-4	66,7%
2 times a week	2-1	0
1 time a week	1-	-
Less than 1 time a week	1-1	16,7%
Less than 1 time a month	-	-
Pain or discomfort when defecating		
Never	0-1	-
Rarely	2-2	33,3%
Sometimes	3-2	33,3%
Usually	1-1	-
Always	-	-
Incomplete evacuation		
Never	0-1	-
Rarely	1-1	-
Sometimes	2-2	33,3%
Usually	2-0	-
Always	1-2	33,3%
Abdominal pain		
Never	0-1	-
Rarely	0-3	50%
Sometimes	6-1	16,7%
Usually	0-1	-
Always	-	-
Time in minutes in the bathroom		
Less than 5 minutes	1-2	33,3%
5 to 10 minutes	2-2	33,3%
10 to 20 minutes	2-2	33,3%
20 to 30 minutes	-	-
More than 30 minutes	1-0	-
Digital maneuvers and type of assistance		
No assistance	6-6	100%
Laxatives	-	-
Digital assistance or enema	-	-
Failed or unsuccessful attempts to evacuate within the past 24 hours		
Never	2-3	50%
1-3	4-2	33,3%
3-6	0-1	16,7%
6-9	-	-
9+	-	-
Duration of constipation in years		
Zero	-	-
1-5	1	16,7%
5-10	1	16,7%
10-20	2	33,3%
20+	2	33,3%
Total average after	10 $\pm$ 3 am	

Source: Prepared by the authors.

In addition, on the Perceived Change Scale (EMP), 83.3% (n=5) of the volunteers reported improvement in mood, ability to endure difficult situations, personal problems, stability of emotions, self-confidence, appetite, sleep and leisure activities, in addition to variables such as ability to fulfill obligations, homework, interest in working, sexuality, energy and interest in life were reported as unchanged, and were shown in Table 4.

Table 4

Distribution of the university students according to the Perceived Change Scale (EMP)

Perceived Change Scale (EMP)			
Do you think the treatment helped you feel better? If yes how? If not, why?	Yes, along with the treatment I started to re-educate myself in eating and I noticed a lot of improvement and easier to evacuate		
	I went to the bathroom more often, consequently making me less bloated and with an improvement in mood		
	Yes, I have been going to the bathroom more often		
	Yes, in the first session at the end of the day I already felt like evacuating		
For each item below since you started treatment is ?	The treatment helped me with frequency and ease		
	I'm going to the bathroom more often with shorter breaks		
	Worse than before	No change	Better than before
Your personal problems	-	33.3% (n=2)	66.7% (n=4)
Your mood	-	16,7% (n=1)	83.3% (n=5)
The stability of your emotions	-	33.3% (n=2)	66.7% (n=4)
Your confidence in yourself	-	33.3% (n=2)	66.7% (n=4)
His interest in life	-	66.7% (n=4)	33.3% (n=2)
Your ability to endure difficult situations	-	50% (n=3)	50% (n=3)
Your appetite	-	33.3% (n=2)	66.7% (n=4)
Your energy	-	33.3% (n=2)	66.7% (n=4)
Your sleep	-	33.3% (n=2)	66.7% (n=4)
Your physical health	16.7% (n=1)	16.7% (n=1)	66.7% (n=4)
Your sexuality	-	100% (n=6)	-
Your coexistence with family and friends	16.7% (n=1)	16.7% (n=1)	66.7% (n=4)
Your coexistence with your friends	-	66.7% (n=4)	33.3% (n=2)
Your coexistence with other people	-	66.7% (n=4)	33.3% (n=2)

Your interest in working	-	50% (n=3)	50% (n=3)
Your leisure activities	-	16.7% (n=1)	83.3% (n=5)
Your homework assignments	-	83.3% (n=5)	16.7% (n=1)
Your ability to meet obligations		50% (n=3)	50% (n=3)
Finally, since you started treatment in general you are?	-	-	100% (n=6)

Source: Prepared by the authors.

Regarding the reapplication of the questionnaires, it was noted that after the treatment there was a small decrease in the *Constipation Scoring System* score of 10 ± 3 , in addition to a decrease in the number of Roma IV criteria marked by 33.3% (n=2) and no significant change in the Bristol scale. Due to the low sample size, it was not possible to find statistical relationships between the variables.

4 DISCUSSION

Regarding sociodemographic data, the present study showed that 50% of the participants were in the age group between 23 and 27 years. Not corroborating with Chase *et al* (2005) who in turn used the interferential current to treat resistant chronic constipation with children aged 7 to 16 years as a sample and with Samhan *et al* (2020) where ages ranged from 7 to 15 years, however, it was similar to the study by Moore *et al* (2020) and Queralto *et al* (2013) where both carried out their studies with individuals over 18 years of age.

Regarding the gender of the sample, Vitton *et al* (2023) obtained about 94.8% of the participants being female, which was assimilated by Moore *et al* (2020), who carried out a randomized clinical trial using the interferential current in a 100% female sample composed of 17 women, which is in line with this study.

As observed in the study by Samhan *et al* (2020), which used the interferential current in the treatment of children with dyssynergic-type constipation, the initial evaluation did not show significant short-term differences in relation to the frequency of fecal incontinence per week and the type of stool assessed by the Bristol scale, which corroborated the present study so that this scale did not present a statistically significant difference, with 16.7% (n=1) having a score of 2 (constipational feces) before and type 4 (healthy feces) after treatment, which indicates an improvement.

In view of the study by Queralto *et al* (2020) it was shown that after applying the interferential current at home for one hour a day for 3 months, patients improved significantly in all scores. Prior to stimulation, most had an average number of stools per week of 0.33 or 0.66, and the highest post-stimulation frequency was 1.66 stools per week, indicating improvement in the criteria for ROMA IV. Similar to the study by Yang *et al* (2017), that after the intervention the average number of bowel movements per week improved from 3.7 to 5.6 in the treatment arm, but not in the placebo group that did not use the interferential current. Corroborating this study where 33.3% reported improvement in the frequency of bowel movements per week, decreased excessive voluntary fecal retention, and painful defecation.

Regarding electrotherapy, Yin *et al* (2023) showed that high-frequency stimulation being administered transabdominally from two different angles at the point converge, so that the stimulation currents interfere with each other, generating stimulation at a differential frequency, thus allowing the stimulation current to penetrate through the abdominal wall to reach the target organ and producing therapeutic effects. Thus, as suggested by Chen *et al* (2023), electrical stimulation during interferential current can activate the vagal sympathetic and parasympathetic nerves of the bowel, but is unlikely to directly stimulate the pelvic floor and external anal sphincter. However, there is still a lack of scientific articles on the efficacy of interferential current, especially double-blind randomized clinical trials with a large sample size, as reported by Moore *et al* (2018).

The findings of the present study corroborate what was found in Chase *et al* (2005) and the study carried out with eight children, which demonstrated that the frequency of defecations increased by 62.5% after treatment with interferential current, also similar to the studies of Clark *et al* (2009) who used interferential current for the treatment of slow transit intestinal constipation where after the use of interferential current in the group Control (n=22) colonic transit was significantly faster than those who received placebo (n=8), however, both studies disagree with the double-blind randomized multicenter trial by Vitton *et al* (2023) which stated that they did not observe significant changes in constipation, but rather in terms of quality of life.

According to Vitton *et al* (2023), quality of life is the most reflective perceived improvement in constipation symptoms and in this study with 160 individuals it was noted that satisfaction in the control group reached the average score on the PAC-QOL (Patient Assessment of Constipation Quality of Life) of 2.75 against 2.50 in the group that received placebo. In the present study, the perception of improvement aspect was assessed by the Perceived Change Scale (EMP), cross-culturally validated by Gentil (2023) so that it was

reported by 83.3% (n=5) of the patients that there was an improvement in mood, in the ability to withstand difficult decisions and improvement resulting from the treatment in general.

In addition to the fact that 83.3% (n=5) reported improvement after treatment in aspects such as personal problems, stability of emotions, appetite, sleep, and leisure activities, this situation was also observed in the study by Zhu *et al* (2018)²⁶ where, after treatment with electrotherapy in cancer patients with intestinal constipation, a significant improvement in quality of life equal to 29.83 ± 6.64 was observed. As well as, in Gokce (2020) who used electrotherapy for 30 minutes 3 times a week over 6 weeks, where a report of subjective improvement was reported in 50% (n=18) of the patients, which agreed with the present study.

Regarding the biopsychosocial model, Lee *et al* (2017) stated that psychosocial factors such as psychological state, characteristics of the individual and stress in life also affect intestinal physiology, compromising the secretory function and mucosal barrier through the alteration of the efferent autonomic nervous system and the stress hormonal system. Therefore, as reported by Gentil *et al* (2023) and Scott *et al* (2021), psychological aspects are of great importance in the treatment of constipation, as well as changes in diet, physical activity, and use of medications, which requires multiprofessional and individualized action.

5 FINAL CONSIDERATIONS

In view of the above, it was possible to observe that the sample is composed of young women, aged between 18 and 27 years, single, and of economic class from B to E. Regarding the criteria for ROMA IV, it was reported that 33.3% of the volunteers had a decrease in the criteria regarding the symptoms of frequency of small bowel movements per week, excessive voluntary fecal retention, and painful defecation. 16.7% had a change in score on the Bristol scale, changing from Type 2- (Constipation) to Type 4- (Healthy stools).

Regarding the Constipation Scoring System scale, it was observed that the patients did not show statistically relevant improvement. A small reduction in the constipation scale of 10 ± 3 was observed. However, improvement in psychological aspects such as mood, ability to withstand difficult situations, sleep, and self-esteem was observed in 83.35% of the patients, an aspect that directly impacts quality of life and is intrinsically related to comorbidity due to the brain-gut model.

The small sample size made it impossible to make any statistical correlations between the groups evaluated, requiring greater scientific production on the subject, which lacks specific studies focusing on the standardization of the application of the method, with a large sample size, in addition to awareness about the lifestyle with continuous and multidisciplinary treatment.

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FROM INSPECTION TO RESILIENCE: HOW EXTERNAL AUDIT CAN CONTRIBUTE TO DISASTER RISK REDUCTION PUBLIC POLICY

DA FISCALIZAÇÃO À RESILIÊNCIA: COMO O CONTROLE EXTERNO PODE CONTRIBUIR PARA POLÍTICAS PÚBLICAS DE REDUÇÃO DE RISCOS E DESASTRES

DE LA FISCALIZACIÓN A LA RESILIENCIA: CÓMO EL CONTROL EXTERNO PUEDE CONTRIBUIR A LAS POLÍTICAS PÚBLICAS DE REDUCCIÓN DE RIESGOS Y DESASTRES



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ABSTRACT

Disasters caused by extreme weather events resulting from climate change tend to increase, thus response structures must adequately prepare to develop risk reduction and event response actions. However, studies that analyze the Brazilian reality show that civil defense structures still have many deficiencies. The Courts of Audit are external audit institutions responsible for auditing accounts prior to the analysis by the Legislative branch. The evaluation format of these courts has evolved towards more qualitative analysis, which can induce the adoption of public policies. The Court of Audit of Paraná implemented ProGov, which modifies the way municipal accounts are evaluated. This study analyzed the evaluation of the accounts of the municipalities in the Urban Core of Curitiba on the Civil Defense theme, based on the parameters of the Court of Audit questionnaire, considering the Sendai Framework and the National Policy for Protection and Civil Defense. It was identified that the municipalities have significant shortcomings in aspects related to planning, information and systems. Deficiencies in the institutional structure were also identified. It was concluded that the evaluation model used by ProGov, which applies many of the requirements of the national and international norms, is able to influence positively in the improvement of the protection and civil defense public policies.

Keyword: External Audit. Resilience. Civil Defense. Court of Audit.

RESUMO

Os desastres causados por eventos extremos decorrentes das mudanças climáticas tendem a aumentar, de forma que as estruturas voltadas ao atendimento devem se preparar adequadamente para desenvolver ações de redução de riscos e resposta aos eventos. Todavia, estudos que analisam a realidade brasileira mostram que as estruturas de defesa civil ainda possuem muitas deficiências. Os Tribunais de Contas são órgãos de controle externo responsáveis pela auditoria das contas previamente à análise do Legislativo. O processo de avaliação destes tribunais tem evoluído para formatos mais qualitativos, o que pode induzir a

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adoção de políticas públicas. O Tribunal de Contas do Paraná implementou o ProGov, que modifica a forma de avaliação das contas municipais. Este estudo analisou a avaliação das contas dos municípios do Núcleo Urbano de Curitiba para a temática de Defesa Civil a partir dos parâmetros presentes no questionário do Tribunal de Contas, levando em consideração o Marco de Sendai e a Política Nacional de Proteção e Defesa Civil. Identificou-se que os municípios possuem grandes defasagens em quesitos relacionados ao planejamento e às informações e sistemas. Deficiências na estrutura institucional também foram identificadas. Concluiu-se que o modelo de avaliação do ProGov, que incorpora vários requisitos das normativas nacional e internacional, possui a capacidade de influenciar positivamente na melhoria das políticas públicas de proteção e defesa civil.

Palavras-chave: Controle Externo. Resiliência. Defesa Civil. Tribunal de Contas.

RESUMEN

Los desastres causados por eventos extremos derivados del cambio climático tienden a incrementarse, por lo que las estructuras de respuesta deben prepararse adecuadamente para desarrollar acciones de reducción de riesgos y respuesta ante eventos. Sin embargo, estudios que analizan la realidad brasileña muestran que las estructuras de defensa civil aún presentan muchas deficiencias. Los Tribunales de Cuentas son órganos de control externo responsables de auditar las cuentas antes de la revisión legislativa. El proceso de evaluación de estos tribunales ha evolucionado hacia formatos más cualitativos, que pueden inducir la adopción de políticas públicas. El Tribunal de Cuentas de Paraná implementó ProGov, que modifica la forma en que se evalúan las cuentas municipales. Este estudio analizó la evaluación de las cuentas de los municipios del Núcleo Urbano de Curitiba en materia de Defensa Civil, con base en los parámetros presentes en el cuestionario del Tribunal de Cuentas, tomando en consideración el Marco de Sendai y la Política Nacional de Protección y Defensa Civil. Se identificó que los municipios presentan deficiencias significativas en aspectos relacionados con la planificación y los sistemas de información. También se identificaron deficiencias en la estructura institucional. Se concluyó que el modelo de evaluación ProGov, que incorpora varios requisitos de las regulaciones nacionales e internacionales, tiene la capacidad de influir positivamente en la mejora de las políticas públicas de protección y defensa civil.

Palabras clave: Control Externo. Resiliencia. Defensa Civil. Tribunal de Cuentas.

1 INTRODUCTION

The most recent reports on climate change projections predict intense impacts on cities because of extreme weather events, with the potential to cause disasters (IPCC, 2023). The impacts of disasters around the world reinforce the concern about the adoption of more assertive actions to reduce risks. There were 358 disasters recorded in the world in 2025, which caused US\$ 224 billion in losses, with 110.2 million people affected and 16,607 deaths (UNDRR, 2026).

The evolution of the discussion on the topic of disaster risk reduction has been developed since the 1990s, with a repeated focus on institutional strengthening actions and a focus on identifying and acting on risks (UNDRR, 2015; Maly, Suppasri, 2020). One of the points reinforced by the Sendai Framework, the document that currently directs actions at the global level, is the governance between the various actors for the direction and enhancement of risk reduction actions (UNDRR, 2015).

In Brazil, the low institutional capacities of municipal civil defenses represent an obstacle to the development of more robust resilience actions (Brasil, 2021; Londe *et al.*, 2023; Marchezini *et al.*, 2025). This makes the development of institutional governance for disaster risk reduction a challenge at the local level.

The concern with municipal capacities for risk management culminated in the Elos project (Brasil, 2021) which sought to identify what the existing gaps were, and later in the ICM - Municipal Capacity Index, which seeks to index the level of development of municipal civil defenses based on objective indicators (Brasil, 2026). The actions are an attempt to present consolidated data on these capacities and to identify more accurately the gaps in local structures. The project identified major weaknesses, such as the lack of dedicated servers and the lack of structure for the development of the work. From this perspective, there is a need to strengthen the structures.

It must be taken into account that, despite the existence of legislation that establishes the guidelines at the national level, it is up to the municipalities to format their administrative structure to comply with these guidelines, and there are many differences between each of the federative entities. However, regardless of the format defined, it is necessary to comply with the obligations established by the legislation (Brasil, 2012; 2020).

The problem lies in the implementation of these guidelines, so that municipalities have a low development of civil defenses, even years after the legislation was established, which is related to structural problems and high turnover (Brasil, 2021; Marchezini *et al.*, 2025). There is a need for actions that induce more effective measures by municipal administrations. In this

sense, the control bodies have a central role in monitoring compliance with actions by the executive branch. According to the CRFB (Brasil, 1988), the Court of Auditors carries out the preliminary analysis and subsequently forwards it to the respective legislative branch for the approval of the executive's accounts. Therefore, they have a fundamental role in monitoring the effectiveness of public policies. Nevertheless, this effective monitoring depends on the inspection format adopted, which has led several courts to seek methodologies for a more qualitative analysis of public accounts (Ribeiro *et al.*, 2020; Schabbach; Garcia, 2021).

As of 2022, in Paraná, the State Court of Accounts (TCE) adopted a new methodology for evaluating accounts, moving beyond financial and accounting analysis to incorporate the analysis of the effectiveness of public policies. This was done by incorporating the effectiveness analysis with the division into nine areas of interest, for which municipalities must present documentation proving the basic elements necessary for the policies (TCE-PR, 2026a).

The study seeks to identify to what extent this new evaluation and inspection mechanism of the State Court of Auditors, as a control body, can contribute to greater efficiency in risk and disaster management actions at the municipal level, based on the analysis of the evaluation of the capacity of the civil defense agencies of the Urban Nucleus of Curitiba (NUC) measured from the new evaluation model of the TCE-PR, ProGov.

The hypothesis is that there are still significant deficits in the structures, and that the more detailed and qualitative evaluation of ProGov, based on legal parameters of the national and state policy of protection and civil defense, has a positive impact on the promotion of the improvement of risk and disaster management actions at the municipal level.

The research has the potential to contribute to the field considering the gap in academic research that deals with the external control of the courts of accounts in civil defense activities. In addition, the findings may provide other views on the work of external control in public administration.

2 EXTERNAL CONTROL BY THE COURTS OF AUDITORS

The performance of the control bodies is provided for in the Constitution of the Federative Republic of Brazil, of 1988, which establishes the list of attributions of the Federal Court of Accounts and provides for the institution of Courts in federal territories with more than 100 thousand inhabitants (Brasil, 1988). The Courts of Accounts, whether of the Union or of other territories, have a specific attribution to evaluate public accounts in order to subsidize the subsequent analysis of the Legislative Branch for approval. There is a mistake in considering the TCE as an auxiliary body of the Legislative Branch, because of the constitutional provision

that establishes the attribution of a prior opinion on the accounts prior to their approval by the legislative branch, since the courts enjoy autonomy and are not linked to the structure of that Branch (Moreira; Vieira, 2003).

The collection capacity and effectiveness of the TCE's activities is based on its intrinsic structure and power that guarantees the application of sanctions. The TCE counselors have the same guarantees as the magistrates, contributing to management autonomy (Moreira; Vieira, 2003). With this responsibility, the agencies are responsible for ensuring that public spending complies with current legislation, to ensure suitability, transparency and public interest.

The controller's autonomy is essential for the effectiveness of inspection and control, as is the provision of adequate and sufficient information by those who owe it and an adequate analysis of those who supervise, in order to allow objective accountability (Quintão; Carneiro, 2015), something that also contemplates horizontal *accountability*, such as the system of checks and balances of the bodies (Schabbach; Garcia, 2021). In this sense, it is necessary to have clear measurement mechanisms that allow a clear analysis of whether or not the requirements are met. It is emphasized that the main objective of public administration is the effectiveness of its services to the population, and that the adoption of more qualified mechanisms for analyzing the implementation of policies that does not depend only on financial and accounting requirements, but allows recognizing whether policies are directed to their primary purposes, is fundamental to exercise the role of external control that seeks to ensure the correct social allocation of available resources (Ribeiro *et al.*, 2020).

Quintão and Carneiro (2015) emphasize the importance of the instruments available for the accountability and *accountability* of public officials and those who exercise political power. However, despite the importance of mechanisms for the inspection and accountability of acts that are not in line with the provisions of the legal system, the authors warn that if there is no proper assessment and application of the sanctions provided, effectiveness is lost.

Although there is a direction of legal competence for evaluation, the evaluation format may vary according to the specific body. Therefore, it is important to consider the procedures of specific agencies. Teixeira (2020) assesses that there is a disparity in the interpretation of the Courts of Auditors, which is visible even in rules that have established interpretation guidelines, such as the Manual of Fiscal Statements, of the Ministry of Finance. However, even with the existing divergences, it is possible to identify common paths such as the search for a more qualified and preventive action (Ribeiro *et al.*, 2020; Schabbach; Garcia, 2021).

The Courts of Auditors have moved from an *a posteriori* control to a preventive and concomitant control, with a monitoring of resources beyond the simple analysis of the accounts

that aims to avoid the waste and misuse of public resources. The focus becomes, therefore, on the effectiveness and results of management, and not just accounting valuation (Ribeiro *et al.*, 2020), expanding the role of public policies by control bodies. The authors identify these characteristics from the COVID-19 pandemic, in which the extensive performance of interpreting the legal limits in consideration of the abnormal situation experienced at the time led to analysis models that were not strictly numerical, but contextualized and qualitative (Ribeiro *et al.*, 2020).

Schabbach and Garcia (2021), discuss the influence of the performance of the Public Prosecutor's Office (MP) and the Court of Auditors as motivators for compliance with educational legislation in Rio Grande do Sul. The authors analyze, contextualizing the evolution of educational legislation for children before school age, how the realization of a cooperation involving MP and TCE, the State Department of Education and the Association of Mayors contributed substantially to the creation of awareness and concern with the theme, fostering compliance with the policy related to early childhood education (Schabbach; Garcia, 2021). Seminars, audits and the production of statistics were carried out and sent to the municipalities so that they could adapt actions to serve children in early childhood education. It was from the technical and informational expertise and knowledge about local public policies that the control bodies were able to act as mediators and articulators for the execution of the PNE goal.

By playing a role of coordination and mediation between the agencies, the control bodies play the role of *fixer*, that is, the one who acts to "facilitate, veto, correct, persuade, arbitrate or bargain so that the execution of the policy proceeds without major problems" (Schabbach; Garcia, 2021, p. 135).

Likewise, the courts of auditors can adopt a proactive and socially responsible posture in the face of catastrophic events, moving from a posteriori inspection to a continuous and constant inspection during the event of the processes, as occurred in the COVID-19 Pandemic (Ribeiro *et al.*, 2020). But in addition, other measures can foster the development of local capacity in responding to disasters, as is the case of updating the methodology of ProGov, of the Court of Auditors of Paraná. ProGov is a system created for the monitoring of sectoral policies (TCE-PR, 2026a). It seeks to evaluate the level of implementation of public policies, going beyond financial and accounting analysis. The system is divided into 9 areas that bring together questions that are sent to the municipalities for response. For a requirement to be considered met, there is a need to insert documentation or other form of proof. Public policies are divided into different themes: education; health; social assistance; procurement and

contracts; financial administration; social security; transparency, control and relationship, and; environment.

The agency also holds events called "TCE Conecta" in different regions of the state of Paraná to explain and promote the actions to control public accounts to municipal entities, explaining this evaluation model (TCE, 2026b).

3 CIVIL PROTECTION AND DEFENSE STRUCTURES

Since the 1990s, with the Yokohama strategy, the aim has been to strengthen actions to reduce disaster risk in the world (Maly, Suppasri, 2020). Currently, the international guideline for addressing risks is the Sendai Framework (UNDRR, 2015), which defines priorities for action involving the ability to identify and map the existing risks in the municipality in order to invest in resilience actions, without disregarding the need to have the capacity to alert the population in a timely manner and respond adequately and quickly to disasters.

In Brazil, the role of establishing the guidelines fell to the National Policy for Civil Protection and Defense (PNPDEC), in 2012 (Brasil, 2012; 2020). Although prior to the Sendai Framework, the PNPDEC dialogues with the existing proposals in the international guideline, especially regarding the need for articulation between the different actors and the need for a transversal approach between policies, with a view to strengthening risk and disaster reduction actions. It defines competencies for the federative entities, detailing the scope according to the level of action. There are several attributions of competence of the municipalities, since the action of developing resilience takes place primarily at the local level. Municipal attributions range from mapping and monitoring existing risks, to monitoring and warning actions, in addition to preparing for intervention in the event of disasters. In addition, it is necessary for municipal employees to have the ability to carry out the procedures to declare an emergency situation, which allows them to request help from other entities. However, although the PNPDEC has been in force for thirteen years, there is still a very large gap between what the legislation provides for and what is done at the municipal level.

This situation is related to a deficit in the municipal capacity to deal with disaster risks, since the civil defense structure, which is responsible for coordinating these actions, is insufficient or even non-existent in some cases, as identified through the Elos project (Brasil, 2021; Marchezini *et al.*, 2023; Londe *et al.*, 2025). Deficiency in risk communication is another weakness identified (Londe *et al.*, 2025).

The deficiency covers both the structural level of the agencies, with insufficient and untrained personnel, and structural, in which there is a lack of basic items such as computers

or vehicles to carry out the work of verifying and mapping risks. Data from the Elos project (Brazil, 2021) show these gaps, based on the participation of 1,993 municipal civil defense agencies. Of these participants, 59% have only one or two civil servants responsible for civil defense. In addition, only 57% are municipal employees and 65% of civil defenses share physical space with another secretariat or agency. 67% of respondents do not have a vehicle and 72% do not have an exclusive landline for civil defense. This lack of institutional and physical structure prevents the full development of the municipality's activities and attributions, which involves risk mapping actions, inspections in risk locations, contingency planning and disaster response actions. In addition, 30% of them stated that they do not have a computer or notebook, showing a technological gap and a fragility that prevents even the registration of occurrences in the federal registration and recognition systems, which limits the arrival of resources to the municipalities.

Disasters are complex phenomena and there is a wide range of interlocations with other public policies, such as the environment, urbanization, social assistance, health and others. The creation of risks is also related to the dialogue with land use and occupation policies, urbanization and economy (Coutinho *et al.*, 2014; Cabral; Cândido, 2019). Therefore, there is a need for professionalization of civil protection and defense agents (Coutinho *et al.*, 2014; Marchezini *et al.*, 2025). The lack of an adequate structure for the development of activities that concern civil defense also makes it impossible for the complex articulation necessary for the development of more effective strategies to be applied.

Therefore, the structuring of municipal bodies is essential for the implementation of activities. Investment actions by the states help municipalities to strengthen the structure at the municipal level (Espírito Santo, 2022; Paraná, 2024; São Paulo, 2025). However, the deficit continues to exist, and there is a need for more consistent activities on the part of the municipalities.

4 METHODOLOGY

The exploratory research based on documentary analysis (Gil, 2025) aims to identify the capacity of the municipalities of the Urban Nucleus of Curitiba in the area of civil defense based on the results of the evaluation of the accounts of the municipalities carried out by the TCE.

The data of scores and responses for the municipalities that make up the NUC - Urban Nucleus of Curitiba were analyzed regarding the subtheme of Civil Defense, present in the environment theme of ProGov. The municipalities that make up the NUC are: Almirante Tamandaré, Araucária, Campina Grande do Sul, Campo Largo, Campo Magro, Colombo,

Curitiba, Fazenda Rio Grande, Itaperuçu, Pinhais, Piraquara, Quatro Barras, Rio Branco do Sul and São José dos Pinhais (Paraná, 2026).

Each item evaluated in the sub-theme is scored dialogically, receiving a score of 0 in case of non-compliance and receiving a score of 10 in case of compliance, always with the documentary validation of the information. Data for the year 2025, available on the TCE-PR website (2026), were evaluated, which refer to the evaluation carried out by the TCE-PR on the declaratory data by the municipalities. The data regarding the scores for the areas and questions were tabulated in Microsoft Excel, allowing the comparison of the information obtained.

After tabulating the data, comparisons were made between the information obtained, identifying the points of fragility and development in this region.

5 RESULTS AND DISCUSSION

The Urban Nucleus of Curitiba (NUC) is composed of 14 municipalities that, for the most part, border the municipality of Curitiba. The total population of the Center is 3,308,949 people, according to data available from the 2022 census carried out by the IBGE (2025).

The information on Civil Defense was integrated within the Environment theme within the report, which brings together information from the following sub-themes: environmental resource management, drainage and rainwater management, environmental urban planning, solid waste, climate change and civil defense. The scores are an average of the information provided, ranging from 0 to 10. Information regarding the Environment theme is only available from the year 2025, since they were only integrated from this reference year through Technical Note No. 34, of September 24, 2025.

It is noted that the focus of the evaluation is concentrated on structuring aspects and the existence of capacities, which contributes to the development of the municipal civil protection and defense agency. The requirements cover several points listed in national legislation and international framework, but which may eventually be expanded to cover other competencies such as interinstitutional governance. The evaluation focuses on key aspects in the development of civil protection and defense policies at the local level.

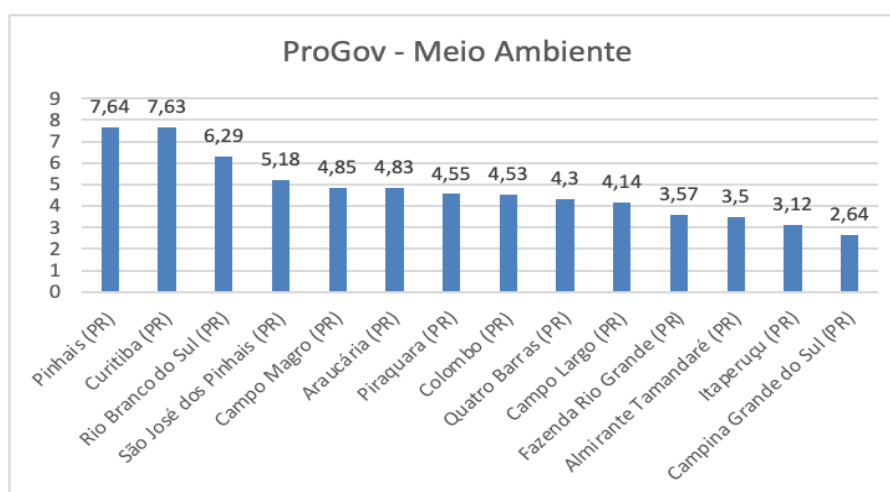
In addition to structural elements, there are elements in the evaluation that analyze the capacity in macro processes, such as the potential for organizing service actions (collection of donations, recovery plan and plan to reestablish essential services), which contribute to a faster and more effective response, in addition to transparency in actions, also demonstrating a focus on *the accountability* of public action.

When analyzing the score of the 14 municipalities of the NUC in the theme of "Environment", only 4 municipalities have scores above 5: Curitiba (7.63); Pinhais (7.64); Rio Branco do Sul (6.29), and; São José dos Pinhais (5.18). The scores allocated below five in the vast majority of municipalities demonstrate that the areas that make up the theme suffer great gaps in their public policies. Figure 1 below presents the scores in the Environment theme by municipality, making it possible to identify the low score in the theme, and that only two municipalities have scores above 7 points.

By opening up to the areas that make up the theme, the specific problems in each sub-theme begin to become more evident, demonstrating the fields in which fragility is greater. In the subtheme of Civil Defense, the main focus of this study, seven municipalities are above 5: São José dos Pinhais, Rio Branco do Sul, Campina Grande do Sul, Araucária, Curitiba, Piraquara and Fazenda Rio Grande. It should be noted, however, that most municipalities concentrate their scores between 4 and 6, indicating the existence of weaknesses in several municipalities, so that they did not achieve more robust scores. The municipalities of Colombo and Itaperuçu draw attention, the first with a score of 3.23 and the second with a score of zero. Itaperuçu did not score in any of the items, indicating that it does not have actions or that there was no answer to the questions related to the area in the questionnaire. Figure 2 presents the general scores of the Civil Defense subtheme for the municipalities of the NUC in descending order. By comparing both Figures, it is possible to verify that the scores in the Civil Defense theme are better scored, globally, than the Environment theme, indicating greater attention to the area. Nevertheless, the score in general is low, with three municipalities only above 7 points.

Figure 1

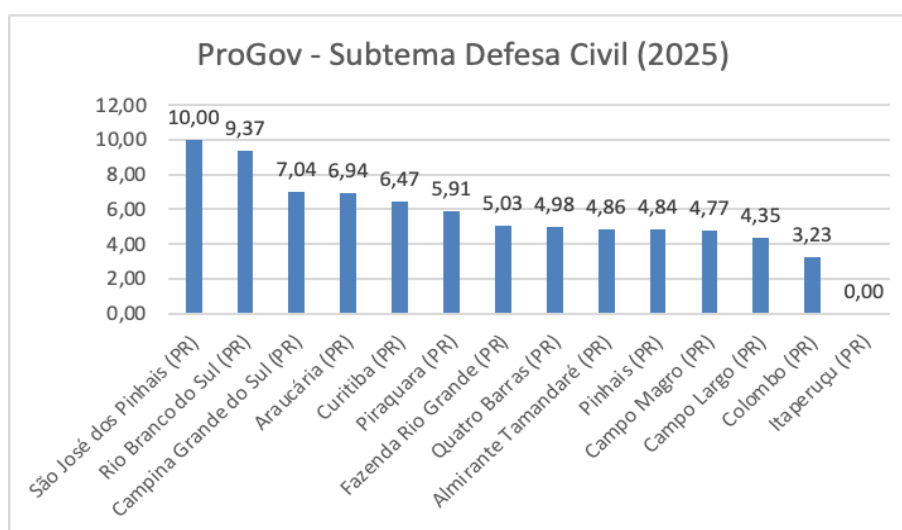
Evaluation regarding the theme of Environment in the municipalities of the NUC-RMC



Source: adapted by the author from TCE-PR (2025).

Figure 2

Evaluation regarding the sub-theme of Civil Defense in the municipalities of the NUC-RMC



Source: adapted by the author from TCE-PR (2025).

The score is indicated from a questionnaire that must be answered by the municipalities. In the sub-theme of civil defense, the questions focus on demand that seeks to assess the existence and quality of the institutional structure of Civil Defense in the municipality, the existence of planning in the area, the availability of physical structure and resources for the agency and the existence and management of data, information and alert system of civil defense. Therefore, it focuses on these issues, although there are other areas that could be encompassed from the relevant legislation.

From the scores in the questionnaires, it can be seen that there is a concentration of efforts in some areas, while in others there are gaps that do not affect only one municipality, but the whole itself. Regarding the existence of formal designation, most municipalities have such designation (12), however in four of them the designated civil servants do not exclusively serve civil defense. Another crucial point in the TCE-PR survey is the existence of a diagnosis that evaluates the need for the number of civil servants that would be necessary to work in the area, in a documented way. Only four municipalities had this data: Almirante Tamandaré; Campina Grande do Sul; Rio Branco do Sul; and São José dos Pinhais. In other words, essential data for adequate planning are not considered and, although the municipalities have designated teams, there is no consistency in the service capacity that these servers represent in the face of the need. It should be noted that institutional development is a requirement for the operationalization of the actions necessary for the development of the civil protection and defense policy, as it is the people destined to the development of the actions, as well as the integration with other areas of the city hall and society that allow the development of the

response capacity and the implementation of actions that develop resilience. The questionnaire requests that people be exclusively dedicated to civil defense, and that they have undergone training in the area of civil defense in the period analyzed, encouraging the structure to be not only existing, but also active and able to develop the actions necessary for the implementation of the national policy of protection and civil defense in their territories.

Other requirements are related to operational capacity. Although 13 municipalities have their contingency plans with the minimum requirements presented by law, only 6 evaluated the effectiveness during the year and only 4 make the information available on the municipal website. In addition, only 3 have actions to encourage volunteering in the municipality, indicating that the alignment of actions with other actors in society remains outside the planning for disaster response, which can harm the efficiency of the response. Conducting simulations is an essential task for evaluating the effectiveness of planning and allows the identification of planning failures, deficiencies in human and material resources, in addition to strengthening protocols with the people and institutions involved, also allowing to assess the completeness, applicability and flexibility of planning (Chen *et al.*, 2015; Shao *et al.*, 2025).

Other deficiencies are related to the ability of municipalities to establish damage assessment processes that combine the areas of essential services, as well as the processes necessary for the survey of damages and losses and the decree of emergency situations and other related processes, necessary for requesting resources from other federative entities, for example. This measure directly impacts the municipality's ability to reach resources from other federative entities, since the decree process has a specific rite and needs speed. It is this process that allows, for example, people within the affected area to use their FGTS, after the federal recognition of the emergency situation. The deficiency in this area limits the response to the emergency and the benefits to the most affected population.

Only 5 municipalities have their own alert systems, in addition to those made available by other federative entities) and only 4 carry out simulations to test these systems. Despite the implementation of the SMS and *Cell Broadcast alert system*, it is perceived that monitoring and alert are deficient, even in locations that have more institutional conditions and physical structure, indicating the need for improvement in systems for the rapid sending of information to the population.

Regarding the available physical structure, most municipalities have a place and vehicles for operation (12), showing a more robust reality than that evidenced at the national level by the Elos project (Brasil, 2021). In fact, with the exception of the municipality of Itaperuçu, which did not score in any of the items, the other thirteen municipalities have scores referring to the

structure above 5, and ten of them have scores above 7, indicating the existence of reasonable physical structure and equipment.

The results show the need to implement civil defense actions in the municipality in a more robust way, especially regarding information and alert systems. In addition, the existence of gaps in the institutional structure, such as the duplicity of activities or the lack of training, make the physical structure and available equipment less efficient. Direct actions in vulnerable communities are a deficiency in most municipalities, and it is necessary to develop capacities at the community level and invest in monitoring and follow-up capacity in risk areas.

6 FINAL CONSIDERATIONS

The Courts of Accounts are responsible for the analysis of municipal accounts, and their performance has been developed in order to carry out a qualitative analysis, which evaluates the efficiency of public policies under the responsibility of the entity evaluated. The ProGov tool of the TCE-PR is an example of the evolution of the evaluation formats of these courts. By implementing tools that cover more than accounting aspects and include questions that seek to assess the actual achievement of objectives, it is possible to induce the improvement of public policies.

By focusing on public policies related to Civil Defense evaluated through ProGov, the present study found that the tool covers structuring and basic aspects of civil protection and defense activities, such as its institutional format, capacity of its components, level of preparation to act in emergencies and availability of monitoring and alarm systems to protect the population. But even though they are fundamental, the municipalities showed great difficulty in achieving all or most of the requirements.

The study showed that the municipalities that make up the Urban Nucleus of Curitiba have important gaps in relation to the requirements listed by the ProGov evaluation. Even though there is a minimum physical structure and equipment for the activities, there are problems related to the institutional structure and the problems related to the planning of civil protection and defense actions, and actions related to the existence of specific data and alert systems, stand out. The lack of contingency plan assessments, more structured protocols for local recovery and administrative processes in cases of disasters, in addition to the lack of municipal alert systems are points that need to be developed by municipalities to improve the quality of care provided to the population.

By establishing the need to increase the score as a requirement for the regular evaluation of the accounts, there is a stimulus for the development of the evaluated aspects. Therefore,

ProGov is a tool with the potential to foster improvement in compliance with the national policy for civil protection and defense, considering that several items listed are provided for in this legislation.

In addition, it was possible to notice a convergence of the findings of the evaluation with the problems identified through the federal government's Elos project, especially those related to the allocation of the municipal structure, which demonstrates convergence and reinforces the appropriate direction of the evaluation in the sense of focusing on essential aspects for the improvement of the performance of municipal civil defenses.

It is concluded that there is a deficit in the capacity of the civil defenses of the municipalities that make up the Urban Nucleus of Curitiba and that the evaluation model has the potential to encourage the strengthening of municipal structures, essential for more efficient actions by the municipalities in the area of risk and disaster management, precisely because it establishes evaluation parameters that require progressive improvement in the score for the approval of public accounts. Such a contribution can help municipalities develop capacities that are aligned with the National Policy for Civil Protection and Defense and the Sendai Framework, in addition to developing local resilience.

This study has limitations related to the availability of the time series of ProGov evaluations for the Civil Defense theme, since the first evaluation took place in 2025. As new evaluations are released, new studies may deepen the results of the questionnaire's time sequence, gauging the rate of improvement.

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**THE (LACK OF) LEGAL PROTECTION OF PREGNANT WOMEN IN PRISON:
THE CHALLENGES FACED BY PREGNANT INMATES AT THE
ANANINDEUA/PA WOMEN'S CUSTODY AND REINTEGRATION UNIT – UCRF**

**A (DES)PROTEÇÃO JURÍDICA DA MULHER GESTANTE NO CÁRCERE: OS
DESAFIOS DAS GRÁVIDAS DETENTAS NA UNIDADE DE CUSTÓDIA E
REINSERÇÃO FEMININA DE ANANINDEUA/PA - UCRF**

**LA (FALTA DE) PROTECCIÓN LEGAL DE LAS MUJERES EMBARAZADAS EN
PRISION: LOS DESAFÍOS QUE ENFRENTAN LAS RECLUSAS
EMBARAZADAS EN LA UNIDAD DE CUSTODIA Y REINTEGRACIÓN DE
MUJERES DE ANANINDEUA/PA – UCRF**



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ABSTRACT

A pregnant incarcerated woman navigates between the roles of "mother" and "criminal," the former referring to something natural, an exclusive role of women; the latter denoting something that transgresses what is established by law, a deviation from what is morally accepted and imposed. When pregnancy intersects with crime and, consequently, with incarceration, the woman's vulnerability becomes clear, making it necessary to have a more careful and cautious approach towards this mother, paying attention to her needs and specificities. Considering the increasing number of women in the Brazilian prison system, including pregnant women and new mothers (INFOPEN, 2018), it is extremely important that issues related to the health of pregnant women and their babies begin to be included, in a meticulous and concise manner, in public policies not only at the state level but also nationally. This article aims to discuss the custody situation and the challenges continuously faced by pregnant women in the Ananindeua Women's Custody and Reintegration Unit, which occur mainly due to the lack of assistance from public policies for these women and even for the unborn child. This is an empirical study, conducted in a prison unit, where it was possible to understand whether or not pregnant women are being protected in prison, revealing a possible lack of state assistance and violation of human rights towards female inmates.

Keywords: Pregnant Women. Prison. Social Imbalance. (Lack of) Legal Protection.

RESUMO

A mulher presa, quando grávida, transita entre os sentidos de “mãe” e “criminosa”, sendo o primeiro termo referenciando-se como algo natural, um papel exclusivo de quem é mulher; o segundo é denotado de algo que transgride aquilo exposto em lei, sendo um desvio do que

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é moralmente aceito e imposto pela. Quando a fase da gestação se cruza com o do crime e, consequentemente com o do cárcere, torna-se cristalino a vulnerabilidade da mulher, fazendo-se necessário a presença de um olhar mais cuidadoso e cauteloso para com essa mãe, atentando-se às suas necessidades e especificidades. Levando em conta o aumento do número de mulheres no contexto prisional brasileiro, sendo essas mulheres gestantes ou recém-mães (INFOPEN, 2018), é de extrema importância que as questões referentes à saúde da gestante e seu bebê comecem a fazer parte, de maneira minuciosa e concisa, das políticas públicas não só estaduais, mas nacionais. O presente artigo tem como objetivo discutir a situação de custódia e os desafios continuamente vividos pelas grávidas no cárcere na Unidade de Custódia e Reinserção Feminino de Ananindeua, que ocorrem, principalmente, pela falta de assistência das políticas públicas para com essas mulheres e, até mesmo, para com a criança que ainda vai nascer. Trata-se de uma pesquisa empírica, realizada em uma unidade prisional, onde foi possível compreender se a mulher gestante tem sido ou não protegida no cárcere, de maneira a revelar uma possível desassistência do Estado e a violação dos direitos humanos para com as apenadas.

Palavras-chave: Gestantes. Cárcere. Desequilíbrio Social. (Des)Proteção Jurídica.

RESUMEN

Una mujer embarazada encarcelada se debate entre los roles de "madre" y "criminal": el primero se refiere a algo natural, un rol exclusivo de la mujer; el segundo denota una transgresión de lo establecido por la ley, una desviación de lo moralmente aceptado e impuesto. Cuando el embarazo se cruza con el delito y, por consiguiente, con el encarcelamiento, la vulnerabilidad de la mujer se hace evidente, lo que exige un enfoque más cuidadoso y cauteloso hacia esta madre, prestando atención a sus necesidades y particularidades. Considerando el creciente número de mujeres en el sistema penitenciario brasileño, incluidas las embarazadas y las madres recientes (INFOPEN, 2018), es fundamental que las cuestiones relacionadas con la salud de las mujeres embarazadas y sus bebés comiencen a incorporarse, de manera minuciosa y concisa, en las políticas públicas, no solo a nivel estatal sino también nacional. Este artículo tiene como objetivo analizar la situación de custodia y los desafíos que enfrentan continuamente las mujeres embarazadas en la Unidad de Custodia y Reintegración de Mujeres de Ananindeua, los cuales se deben principalmente a la falta de apoyo de las políticas públicas para estas mujeres e incluso para el feto. Se trata de un estudio empírico, realizado en un centro penitenciario, donde fue posible comprender si las mujeres embarazadas están siendo protegidas o no en prisión, revelando una posible falta de asistencia estatal y una violación de los derechos humanos de las reclusas.

Palabras clave: Mujeres Embarazadas. Prisión. Desequilibrio Social. (Falta de) Protección Legal.

1 INTRODUCTION

The incarcerated woman, when pregnant, moves between the meanings of "mother" and "criminal," the former referring to something natural, a role and vocation exclusive to one who is a woman; the latter denoting something that transgresses what is set forth in law, a deviation from what is morally accepted and imposed by society with respect to the female sex.

The status traditionally assigned to women is that of mother, such that there are requirements considered to be at odds with the commission of a crime, whatever it may be. The exercise of sacrifice that motherhood produces differs, instantly, from life in prison, since her home and her child are placed within a prison, so that both are watched, taught, and disciplined through parameters that are often inadequate for the place to be called a family home, whether that child is in her womb or in her arms.

In the view of Gilles Deleuze:

it is a kind of ball of yarn or skein, a multilinear ensemble. It is composed of lines of different natures, and these lines of the apparatus do not encompass or delimit homogeneous systems on their own account (the object, the subject, language), but follow different directions, form processes that are always in disequilibrium, and these lines both approach and move away from one another. Each line is broken and subject to variations in direction (forked, bifurcated), subject to derivations. The visible objects, the formulable enunciations, the forces in exercise, the subjects in a given position, are like vectors or tensors. (DELEUZE, 1990, p. 155).

It is thus possible to perceive that the term "criminal" ends up absorbing the term "mother" when it comes to life in prison, much like the principle of *consumção* (consumption/absorption) [[nota: "Consumção" é princípio do Direito Penal brasileiro; mantido o termo original com tradução aproximada entre parênteses, por não haver equivalente exato consagrado em inglês]] belonging to Criminal Law. This occurs, above all, because of the absence of spaces in which the woman can be heard, since the commission of a crime, besides invalidating the term "mother," does not allow any defense for this woman who has long found herself jammed, choked, and limited, answering only what she is asked, and, if asked, being entirely delegitimized as a mother.

It is clear that in Brazil access to justice occurs in a precarious and unequal manner, especially when it comes to economically disadvantaged persons (*hipossuficientes*) [[nota: "hipossuficientes" é termo jurídico para quem não dispõe de recursos econômicos; mantido o original entre parênteses]]. It is no different for incarcerated mothers (whether pregnant or with their children in their arms), considering that these women are, for the most part, Black

and poor women, involved in crimes in an attempt to ensure their family's livelihood or to try to structure their homes.

Furthermore, many of the problems and difficulties that these mothers experience do not reach the State Public Defender's Offices (Defensorias Públicas Estaduais), which end up unable to be present within the prison unit, specifically within the Mother and Child Unit (UMI – unidade materno infantil), causing a lack of communication between the incarcerated woman and her defender, which, in the case of pregnant women, ends up harming the progress of the pregnancy, given that the lack of follow-up causes uncertainty about the real development of the child.

The objective of this article is nothing more than to dwell on the offcuts of feminist criminology and to discuss why legal-criminal discourses and practices bring to the surface the values and rights that incarcerated pregnant women possess but which, regrettably, are not safeguarded—these rights being disrespected day after day within a prison, and even outside it, taking into account the contempt of society (and even of the family) toward this woman who committed a criminal act and ends up being devalued as a mother.

2 THEORETICAL FRAMEWORK

2.1 THE INTERNATIONAL AND NATIONAL NORMATIVE STRUCTURE PROTECTING THE PREGNANT WOMAN IN PRISON

2.1.1 Protection in the Universal International Human Rights System

In a woman's life, the moment of pregnancy is one of the most important; it signifies, besides something peculiar and full of feelings, a moment that requires a series of cares for her health and the health of the baby.

When the stage of pregnancy intersects with that of crime and, consequently, with that of prison, the woman's vulnerability becomes crystal clear, making it necessary to have a more careful and cautious gaze toward this mother, attending to her needs and specificities. Considering the increase in the number of women in the Brazilian prison context, these being pregnant women or new mothers (INFOPEN, 2018), it is extremely important that issues concerning the health of the pregnant woman and her baby begin to form part, in a thorough and concise manner, of public policies that are not only state-level but national.

In the Brazilian political scenario, in the face of a setting of invisibility, the violence and neglect in which women in prison are inserted bring to the surface the importance of promoting reflections on the Brazilian female prison system, such that the principle of human dignity is established as fundamental—which, besides being a principle explicitly present in

the Federal Constitution of 1988, is one of the greatest, if not the greatest, pillar of human rights.

The Universal Declaration of Human Rights (1948) seeks, in an objective and concise manner, to outline a consecration of basic universal values, having enshrined human dignity as the founding value of the fundamental rights present in Article 5 of the Federal Constitution of 1988, which inspires the world legal order, since it effectively holds supreme value (SILVA, 2000), constituting an important structure for the organization of the State.

In this sense, in the face of the reconstruction of the legal world with the inclusion of human values (BARROSO, 2013, p. 18), Luís Roberto Barroso advances a positive interpretation of the norm, which was and is motivated by ethics:

[...] Human dignity was incorporated into the political discourse of the victors as one of the bases for a long and awaited era of peace, democracy, and the protection of human rights. Human dignity was then imported into legal discourse owing to two main factors. The first was the inclusion, in different international treaties and documents, as well as in various national constitutions, of textual references to human dignity. The second factor corresponds to a more subtle phenomenon, which became more visible over time: the rise of a post-positivist legal culture, which brought law closer again to morality and political philosophy, attenuating the radical separation imposed by pre-World War II positivism (BARROSO, 2013, p. 18-19).

Accordingly, the Federal Constitution of 1988 is nothing more than a mirror of the constant metamorphosis that accompanies the perspective of rights (PIOVESAN, 2013, p. 96). Nonetheless, it is still notable that Brazil lacks policies that would make the State act to protect the minority that, regrettably, has been forgotten day after day by society. Moreover, a punitive culture is currently experienced toward those who commit unlawful acts, especially pregnant women, revealing the social anomie so emphasized by the sociologist Émile Durkheim (*A Educação Moral* [Moral Education], 1902) [[nota: título da obra mantido no original (português) conforme citado, com tradução aproximada entre colchetes]], since there is a failure of public policies—it being far easier to believe that "a good criminal is a dead criminal" [[nota: tradução do ditado "bandido bom é bandido morto"; expressão idiomática brasileira, traduzida pelo sentido]] than to acknowledge the share of blame, small or not, that society itself bears for the deterioration of the harmony of resocialization (SANTOS, ÁVILA, 2017, p. 273-274).

The total disregard for fundamental rights is potentially revealed in prison, being extraordinarily intensified in women's prisons, especially in the wings designated for incarcerated pregnant women (MENDES, 2017, p. 215).

2.1.2 United Nations Standard Minimum Rules for Non-custodial Measures

The process of universalization of human rights following the Universal Declaration of Human Rights of 1948 allowed for the formation of an international and national protection of these rights, composed of international protection treaties and a series of conventions that deal with this on a daily basis.

In view of the United Nations' growing concern with the humanization of criminal justice, the need was observed to consolidate principles and rights committed to the protection and humanization of persons within prison, thus giving rise to the Tokyo Rules, or the United Nations Standard Minimum Rules for Non-custodial Measures [[nota: o título da seção corresponde às "Regras de Tóquio", cujo nome oficial em inglês é "United Nations Standard Minimum Rules for Non-custodial Measures (the Tokyo Rules)"]], which aim at building a more highly humanized model in the distribution of justice.

Brazil, the country with the 3rd-largest prison population (CNJ, 2025), still faces daily problems in its prisons, with the lack of structure and overcrowding being some of them, which prevents the existence of more structured departments to receive pregnant women so as to support them and, in the future, ensure that the maternal bonds between these mothers and their children are not lost—given that most prison establishments were designed to house the male population, causing countless challenges in these women's lives, the principal one being the lack of medical assistance for prenatal follow-up (INFOPEN Mulheres, 2014, p. 13).

The Tokyo Rules are essential to ensure that the health and, above all, the rights of incarcerated pregnant women are handled in an appropriate manner—respected and complied with daily, before, during, and after pregnancy—so that the participation of these women in the criminal justice process is promoted, also developing responsibility toward the babies yet to be born and toward society, without discrimination as to the economic or social situation of the incarcerated woman.

[...] 1.4 In applying the Rules, Member States shall endeavor to ensure a proper balance between the rights of offenders, the rights of victims, and society's concern with public safety and crime prevention. 1.5 Member States shall develop non-custodial measures within their legal systems to provide other options, thereby reducing the use of imprisonment and rationalizing criminal justice policies, taking into account respect for human rights, the requirements of social justice, and the rehabilitation needs of offenders. (CNJ, 2016, p. 15)

2.1.3 Standard Minimum Rules for the Treatment of Prisoners

For years, States used the Standard Minimum Rules for the Treatment of Prisoners as the main legal-normative structure to organize the framework and criminal justice, until their reform in May 2015, when the existence of the most varied international instruments in

force—acting in the protection of prisoners' human rights—was analyzed, with a more careful gaze toward situations involving children, adolescents, and women deprived of liberty.

In women's prison units, there shall be special accommodation for all needs of pre- and postnatal care and treatment. Specific procedures shall be adopted so that births occur in a hospital outside the prison unit. If the child is born in the prison unit, this fact shall not appear on the birth certificate. Rule 29(1). The decision to allow a child to stay with their father or mother in the prison unit shall be based on the best interests of the child. In prison units that house children of detainees, provisions shall be made to ensure: (a) internal or external nurseries staffed by qualified personnel, where children may be left when not under the care of their father or mother; (b) pediatric health services, including medical screening upon admission and constant monitoring of their development by specialists. (CNJ, 2015)

Before the amendment made in 2015, nothing was said regarding pregnant women in labor, leaving them at the mercy of fate; afterward, small things changed, such as the prohibition on the use of handcuffs during labor and the postpartum period. It happens that, regrettably, the Mandela Rules [[nota: "Regras de Mandela" — nome oficial em inglês: "the Nelson Mandela Rules"; refere-se à versão revista (2015) das Standard Minimum Rules for the Treatment of Prisoners]] have little repercussion in national public policies, which demonstrates the country's deficiency in achieving a greater valorization of these norms protecting prisoners' human rights.

The lack of infrastructure is still an exorbitant deficiency not only in women's prisons but in the very base of Brazilian society, demonstrating the State's and public entities' total lack of commitment to upholding the rights of pregnant women in prison and their babies.

Nana Queiroz (QUEIROZ, 2020, p. 103), in her book *Presos Que Menstruam* [[nota: título do livro mantido no original conforme regra de não tradução de títulos; tradução literal: "Prisoners Who Menstruate"]], reports:

In general, each woman receives two rolls of toilet paper per month (which may be enough for a man, but never for a woman, who uses it for two distinct needs) and two packages with eight sanitary pads each. That is, a woman with a four-day menstrual period has to manage with two pads a day; a woman with a five-day period, with less than that, since those provided to them are not able to meet their needs throughout the entire menstrual period. (QUEIROZ, 2020, p. 103).

It must be stressed that it is not only today that this, and many other particularities of the female sex, are disrespected, which includes the particularities of pregnant women, making it crystal clear that women are the most harmed within prison—for if even they do not enjoy their rights, much less their babies—considering that the pregnant woman in prison is

seen as, besides a criminal, illegitimate in the role of mother, as Professor Luana Hordones sets forth (GLOBO, online, 2018).

When a woman is imprisoned, it is as if she committed two crimes, because besides breaking the law she also violated the social role given to her, which is that of being a woman. It is as if the woman were not seen as a being in society who performs the same activities as a man. Our society greatly rejects the criminal woman. This can indeed be a major factor in their being visited less. (GLOBO, online, 2018)

This psychological suffering caused by abandonment in prison must be emphasized. It occurs not only because she is viewed poorly after committing a crime, but because the lack of women's prison units often relocates the inmate to other cities, making the distance from her family even greater—especially because these women are, for the most part, low-income people, which is why they end up becoming involved in crime to ensure the household's livelihood, making it difficult for close relatives to travel to other cities on visiting days.

This proves the State's negligence with respect to women and children in prison, since, even with the advancement of laws—even with the creation of a national plan aimed at pregnant women in prison—the uncertainty regarding the future of these women and their children still persists, confirmed even more strongly by the teachings of Vieira and Veronese:

[...] there are prison units that do not have gynecologists, gynecological tables, sterilizers for gynecological instruments, or medicines, among other deficiencies, which means that prenatal consultations either have to be carried out outside the penal establishment or, when carried out there, suffer from a precariousness of resources and a deficiency of medical equipment and instruments (VIEIRA; VERONESE, 2015, p. 169).

Accordingly, the growing need for efficiency in public policies must be emphasized, for even with a diversity of rights and guarantees belonging to pregnant women in prison and their children, the State's abandonment of these persons causes the palpable feelings of frustration and fear, which mix with the growing anger caused by this inattention—after all, the pain of being abandoned by the one who should ensure your protection is immeasurable.

2.1.4 United Nations Rules for the Treatment of Women Prisoners and Non-custodial Measures for Women Offenders

A priori, for philosophy, prison signified confinement; that is, the imprisoned person was separated from society, from their family circle, and from their social environment, with the aim that they reflect on their behavior deemed criminal, such that their removal from

society was nothing more than a punishment. Thus, the objective of prison was, no more and no less, the resocialization of the prisoner, so that, once the sentence was served, they could return to society and their ordinary social life (ANDRADE, 2018).

Criminal Law has the purpose of regularizing the coexistence of individuals, so as to determine rules and norms in society. For, as Cesare Beccaria states in his book *Dos Delitos e Das Penas* [[nota: título mantido no original conforme citado; obra de Beccaria, conhecida em inglês como "On Crimes and Punishments"]]:

"he rose, in the name of humanity and reason, against the legal tradition and the criminal legislation of his time, denouncing secret trials, the tortures employed as a means of obtaining proof of the crime, the practice of confiscating the condemned person's property." One of his theses is the equality, before the law, of criminals who commit the same offense. His ideas spread rapidly throughout the civilized world, being applauded by Voltaire, Diderot, and Hume, among others, and his work exerted a decisive influence on the reformulation of the legislation in force at the time, establishing the concepts that followed. (BECCARIA, 2007, p. 30)

Beccaria (2007), in his book, shows the failure of criminal legislation toward the prisoner, since there is a notable deficit in the prison system, rendering it precarious, further asserting that there was no one who took an interest in this precariousness to the point of reformulating the legislation and ensuring a good existence within prison, which would bring about better resocialization.

In this sense, there is an urgent need to reflect, continuously and daily, on the reality of pregnant women in prison, such that the sentence must be just both for the mother and for her child, whether born or not, offering elements that contribute to the process of humanization and resocialization of these persons.

The emergence of the Bangkok Rules (CNJ, 2016) arose from the crucial need to align the guidelines contained in the Brazilian legal system regarding the treatment of women in a situation of incarceration, so that improvements in care policies for non-custodial measures could be effected, with special attention to those who are pregnant or with children within the prison system—a group that finds itself under the power of the State, however flawed it may be.

However, although the rules contain requirements to be met, the treatment given to pregnant women in prison goes against the legislation, being in nonconformity with the principle of human dignity, as Araújo (2018) adds:

The rights of pregnant prisoners must be guaranteed. The State must provide minimum conditions of health and dignity for the pregnant prisoner. It is inadmissible,

in a democratic state governed by the rule of law, to violate the fundamental rights and guarantees of pregnant prisoners. (ARAÚJO, 2018, p. 18).

The CNJ (2016), in correlating the Bangkok Rules with the situation of pregnant women in prison, states that:

These Rules propose a differentiated view of gender specificities in female incarceration, both in the field of criminal sentence enforcement and in the prioritization of non-custodial measures—that is, measures that prevent the entry of women into the prison system. (CNJ, 2016, p. 10).

Thus, despite being a collaborator in the effectiveness of the Bangkok Rules, Brazil still lacks efficiency in public policies aimed at this population, causing gaps and scarcity in the applicability of these rules in practice, prompting the STF (Supremo Tribunal Federal – Federal Supreme Court) to present interpretations of the rules, seeking to analyze the possibility of reducing the female prison population, confirming proposals to replace pretrial detention with house arrest for pregnant women and mothers of children up to 12 years of age.

Headnote: COLLECTIVE HABEAS CORPUS. ADMISSIBILITY. BRAZILIAN DOCTRINE OF HABEAS CORPUS. MAXIMUM EFFECTIVENESS OF THE WRIT. IMPRISONED MOTHERS AND PREGNANT WOMEN. MASSIFIED AND BUREAUCRATIZED SOCIAL RELATIONS. VULNERABLE SOCIAL GROUPS. ACCESS TO JUSTICE. FACILITATION. USE OF ADEQUATE PROCEDURAL REMEDIES. ACTIVE STANDING. ANALOGOUS APPLICATION OF LAW 13.300/2016. PREGNANT WOMEN OR WOMEN WITH CHILDREN UNDER THEIR GUARDIANSHIP. PRETRIAL DETENTIONS SERVED UNDER DEGRADING CONDITIONS. INADMISSIBILITY. DEPRIVATION OF PRENATAL AND POSTPARTUM MEDICAL CARE. LACK OF NURSERIES AND DAYCARE CENTERS. ADPF 347 MC/DF. BRAZILIAN PRISON SYSTEM. UNCONSTITUTIONAL STATE OF AFFAIRS. CULTURE OF INCARCERATION. NEED FOR ITS OVERCOMING. PRECAUTIONARY DETENTIONS DECREED IN AN ABUSIVE AND UNREASONABLE MANNER. STATE'S INABILITY TO ENSURE FUNDAMENTAL RIGHTS TO INCARCERATED WOMEN. MILLENNIUM DEVELOPMENT GOALS AND SUSTAINABLE DEVELOPMENT GOALS OF THE UNITED NATIONS ORGANIZATION. BANGKOK RULES. EARLY CHILDHOOD STATUTE. APPLICATION TO THE CASE. ORDER GRANTED. EX OFFICIO EXTENSION. (STF, HC 143641 / SP. JUSTICE RICARDO LEWANDOWSKI). X – Incidence of broad international regulation relating to Human Rights, in particular the Bangkok Rules, according to which judicial solutions that facilitate the use of penal alternatives to incarceration must be prioritized, especially in cases where there is not yet a final and unappealable conviction. (STF, HC 143641 / SP. JUSTICE RICARDO LEWANDOWSKI). XI – Care for the imprisoned woman is directed not only at her, but equally at her children, who unjustly suffer the consequences of imprisonment, in flagrant contradiction to Article 227 of the Constitution, the content of which determines

that absolute priority be given to the realization of these children's rights. (STF, HC 143641 / SP. JUSTICE RICARDO LEWANDOWSKI).

The Bangkok Rules represent a completeness regarding the fundamental rights and guarantees of incarcerated women, in particular pregnant women. However, although these rules are embraced by Brazilian legislation and demonstrate hope for an improvement in the criminal justice of these women through alternatives in the application of the sentence, it is nothing more than utopia; for when placed before the reality of incarcerated pregnant women, the Bangkok Rules end up losing their value, since the deficit in the Brazilian legal system for complying with these rules only becomes more pronounced, rendering these women's lives precarious, bordering on destitution.

3 METHODOLOGY

3.1 NATIONAL PROTECTION OF PREGNANCY IN PRISON

3.1.1 Constitutional Foundation

It is very perceptible that the situation of women in prison only increases each year, growing in a disorderly manner, and that, even after so many changes over the decades, this fact is still a very present problem in Brazilian society.

In the past, women were forced to share cells with the male population, since there were no specific prisons. Today, it is known that there are male prisons and female prisons; however, the country's growth was not accompanied by public policies efficient enough to ensure the effectiveness of the rights belonging to incarcerated persons, especially pregnant women.

The Federal Constitution of 1988 establishes that parents have the duty to care for, protect, and educate their children; it happens that incarcerated mothers are prevented from exercising their role as mothers by the omission of the State, which leaves them without any kind of structure or support.

The non-fulfillment of the precept established in the Federal Constitution is due not only to the terrible structure of women's prisons, but mainly to the lack of services aimed at the health of the mother and her child—before, during, and after pregnancy—since even something as basic as a sanitary pad or a diaper is denied to these women, who often end up depending on a relative's visit in order to have access to it.

In some of the items contained in Article 5, the Magna Carta [[nota: "Carta Magna" é a designação usual, no Brasil, da própria Constituição Federal; traduzido por "Magna Carta", mas no contexto refere-se à Constituição de 1988]] informs us about the establishments necessary for the pregnant woman to serve her sentence (Article 5, item XLVIII), as well as

informing about the protection of the child, making clear that this protection is one of the most important social rights of the Brazilian legal system (Article 6)—which ends up becoming void when it comes to children born and raised within prison, children who, even with safeguarded rights, have them violated day after day.

The need for environments within the prison designated for women's needs goes far beyond the differences between the male and female genders, having everything to do with the support that should exist for women during and after the period of pregnancy, and for their children, who should live in a dignified and healthy place.

Although the Constitution, in Article 5, item L, defines breastfeeding as a fundamental guarantee of the pregnant woman, the State does nothing to ensure the permanence of the maternal bond, for it is common knowledge in society that breastfeeding intensifies the affective bond between mother and baby; however, after the children are handed over to some relative (generally the grandmother), this bond is cut—after all, what mother wants to see her child suffering needs caused by the State's lack of assistance?

Hence, the need to protect these mothers and their children is of paramount importance, since these children will be the base of society, and there is nothing more painful than having something imposed on a child without their mother by their side to support and ensure safety and care.

3.1.2 Infraconstitutional Foundation

With respect to infraconstitutional legislation, the LEP (Lei de Execução Penal – Penal Execution Law) [[nota: mantida a sigla original LEP com expansão e tradução aproximada entre parênteses, conforme regra 5]] stands out in an "exemplary" manner, addressing a series of rights and guarantees referring to pregnant women in prison.

According to the LEP, women's prisons should have an infrastructure entirely divergent from reality, for besides nurseries and places designated for daycare to accommodate their children, the female prison must have professionals who provide qualified personal care as well as medical assistance to the woman both in the prenatal and postpartum periods, extending to the newborn. Nonetheless, it is known that many mothers do not have adequate medical follow-up, such that the insecurity of knowing whether or not their child is well spreads throughout the body of this mother.

Furthermore, it is important to highlight Law 13.257/2016, which made the Code of Criminal Procedure, in its Article 318, provide for the possibility of replacing pretrial detention with house arrest for the pregnant woman—which, even with so much effort to ensure that the incarcerated woman exercises her role as a mother, still suffers various daily violations,

since these women have no contact with their public defenders (who end up sidelining them), and thus do not know their rights or the status of their proceedings.

3.2 THE PRISON SYSTEM AND ITS (DYS)FUNCTION

3.2.1 Care for Women in the Prison System

Currently, the Brazilian prison system has as its objective the resocialization and the "punishment" of those who act with some criminal conduct. Thus, the State assumes responsibility for those who are in prison, isolating them with the aim of combating crimes in society, avoiding risks.

Although nowadays, in theory, punitive techniques are not permitted, the deficit in prison is still quite notable, causing the social anomie that the sociologist Émile Durkheim (1902) so often speaks of, conceptualized as a state of disobedience to the norms and rules imposed by the State on society, causing disharmony among individuals and making resocialization even more difficult—for neither does prison prepare the individual for resocialization, nor is society prepared to allow it.

The reality in prison ends up becoming a delicate subject, in view of the subhuman conditions of precariousness in which the detainees find themselves, considering that prisons have become, over the years, no more and no less than a conglomeration of people, in which overcrowding, lack of hygiene, and lack of medical assistance are causes of irreversible physical and psychological trauma.

Thus, Mirabete (2008, p. 89) expresses:

The failure of our prison system has been pointed out, rightly, as one of the greatest ills of the Brazilian repressive model, which, hypocritically, sends the convicted to penitentiaries with the proclaimed purpose of rehabilitating them for social coexistence, but already knowing that, upon returning to society, this individual will be more unprepared, disoriented, insensitive, and probably with greater skill for the practice of other crimes, even more violent than the one that led him to prison. (MIRABETE, 2008, p. 89)

Throughout the world, there is the exponential growth of women incarcerated for committing offenses, which proportionally increases the number of mothers within prison, whether their children are born or not. It is possible to state that among the main factors for this increase are: unemployment, family livelihood (considering that the woman is seen as the mainstay of the home), relatives in drug trafficking (especially husbands), and, consequently, the influence of their partners.

Silva (2015) analyzes the contrast that occurs in a child's life when their father or mother is imprisoned. Male incarceration is accompanied, for the most part, by the certainty

that the child left by the father will have a caregiver—a role generally occupied by the child's mother, who offers the comfort and support the child deserves, while continuing to maintain contact with her incarcerated partner, enabling the meeting between father and child. Female imprisonment, on the other hand, is marked by despair, by imprecision and uncertainty regarding the fate of the child, since it is common for the father to end up abandoning this child, withdrawing from care and responsibilities, or for him also to be in a situation of imprisonment. Accordingly, this opens the way to a process of concern regarding the possible lack of a support and protection network that this child will have.

Furthermore, Matos, Costa, and Silva (2019) stress that, when it comes to pregnant women, the problem is even greater, for special care must be present regarding the continuity of the pregnancy, the treatment of illnesses, preparation for childbirth, and the treatments the mother must receive after giving birth, as well as her child after birth, thus setting forth:

Female prison exposes specificities correlated to gender—such as issues of reproductive and child health, of social protection and assistance for motherhood and childhood in this environment—which reflect, in the contemporary ethical-legal context, human rights recognized at the international and national levels. (MATOS; COSTA E SILVA, 2015, p. 2).

Vieira and Veronese (2018) also set forth:

Prenatal assistance would be the privileged moment to identify the impacts of the violence of the environment in which the incarcerated pregnant woman is inserted, and would constitute a unique opportunity to seek, if not the interruption of the violence (because that is impossible), at least the offering of special care, with measures appropriate for pregnant women in a situation of violence. (VIEIRA E VERONESE, 2018, p. 7).

Moreover, it is necessary to understand the other dimensions that female incarceration causes not only to the mother but also to the fetus—biopsychosocial consequences that directly influence the development of the maternal bond.

The National Plan for Criminal and Penitentiary Policy (Plano Nacional de Política Criminal e Penitenciária) addresses actions that reinforce and ensure prenatal care, as well as the existence of spaces within prisons aimed at the continuity of pregnancy and the permanence of children with their mothers in the prison environment, with these mothers to be referred to external health units in the absence of such components.

It is notable that there has been development of the prison system over time, with the creation of laws of greater protection for women, especially pregnant women and their children; nonetheless, it is important to emphasize that there are still failures in the

penitentiaries, which only increases the insecurity and the guilt that the woman carries for exposing her child to this situation.

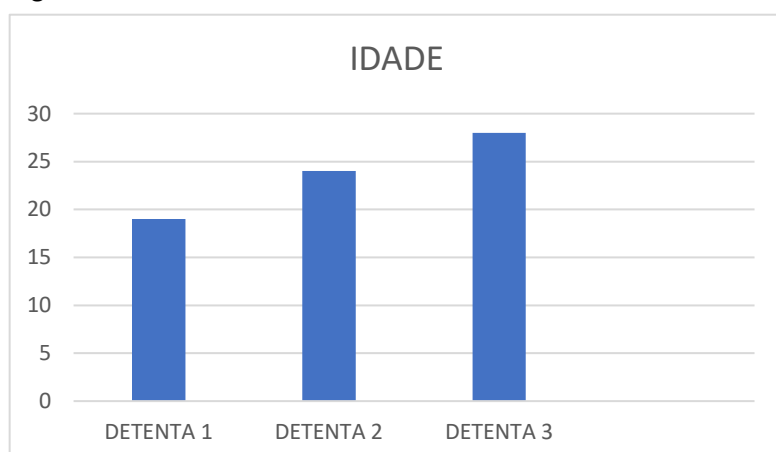
4 RESULTS AND DISCUSSION

4.1 THE CHALLENGES OF PREGNANT INMATES AT THE UNIDADE DE CUSTÓDIA E REINserÇÃO FEMININO DE ANANINDEUA – UCRF

In a questionnaire administered to the inmates who volunteered to participate (identified as INMATE 1, INMATE 2, and INMATE 3) [[nota: "DETENTA" traduzido como "INMATE"; mantida a consistência ao longo do texto]] at the Unidade de Custódia e Reinserção Feminino de Ananindeua – UCRF, on October 19, 2023, the following responses were obtained:

Figure 1

Age chart of the interviewed inmates



Source: Prepared by the authors, based on data collected through a questionnaire on October 19, 2023

Figure 2

Chart confirming the pregnancy of the interviewed inmates

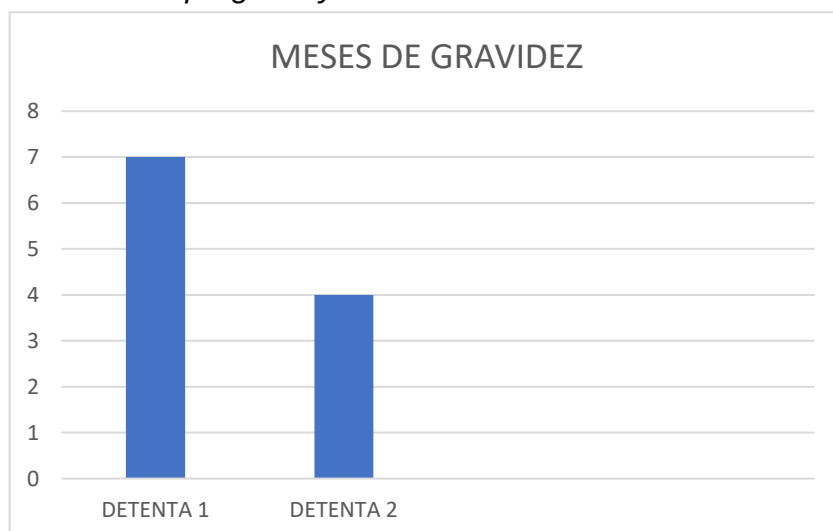


Source: Prepared by the authors, based on data collected through a questionnaire on October 19, 2023

In the table on the pregnancy question (FIGURE 2), it is possible to perceive that of the 3 inmates, 2 of them are pregnant—namely, INMATE 1 and INMATE 2—at which point a specific question was directed to them (FIGURE 3):

Figure 3

Chart of the pregnancy duration of the interviewed inmates



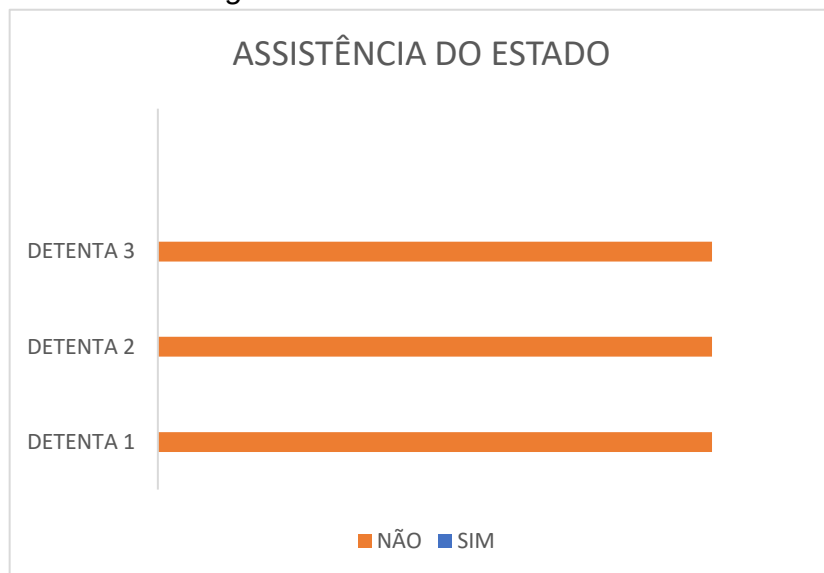
Source: Prepared by the authors, based on data collected through a questionnaire on October 19, 2023

It happens that both demonstrate immense dissatisfaction when questioned about the duration of pregnancy, for they claim to receive no medical treatment for prenatal follow-up, being covered by uncertainty about the health of their children, since they have not even had an ultrasound or consumed the vitamins intended for pregnant women, knowing the gestational week only from calculations made by themselves.

In the following table (FIGURE 4), the State's lack of care toward these women will be demonstrated.

Figure 4

Chart confirming State assistance



Source: Prepared by the authors, based on data collected through a questionnaire on October 19, 2023

It is crystal clear that there is a lack of public assistance for women in prison, for the State in no way aids in the protection and guarantee of the rights of incarcerated pregnant women, nor in the maintenance of the affective maternal bond with their children, and likewise it does not protect these children while still in their mothers' wombs, leaving them at the mercy of fate that everything will turn out well.

Throughout the questionnaire, it was possible to perceive that these inmates receive a visit from only one person: their mother. The grandmother becomes responsible for the care of the grandchild after the child is handed over, once the period of stay with the mother in prison ends—a period that the 3 inmates affirm is no longer than 1 year, even though they were informed that the child will remain until the age of 2.

Moreover, the State also does not assist the grandmother who will care for her grandchild with donations of diapers, clothing, or a layette, leaving it to her to act on her own in raising the child. Thus, it is also possible to perceive the father's abandonment of his partner and child, fleeing from his obligations and responsibilities.

It is for reasons of abandonment that female imprisonment causes so much uncertainty and worry—after all, if these inmates did not have a living mother, with whom would their children stay? Unfortunately, it is known that there are few relatives one can call family, which would leave no alternative for the children but a temporary home, which only

increases the fragility of the woman in prison, since the maintenance of the maternal bond is indispensable for both sides—a bond that would be completely lost if INMATES 1, 2, and 3 did not have their mothers to turn to.

Furthermore, what most drew attention during the questionnaire was the behavior of INMATE 3, mother of 2 children outside prison who are cared for by the grandmother, and of a baby boy of only 10 months who resides with her in the unit. Her behavior throughout the entire questionnaire was one of revolt, anger, rage, and repulsion—not because of the questionnaire itself, but because of the system. The inmate states that her son has never been seen by a doctor and that neither of them received follow-up during the pregnancy and after the child's birth.

"It is absurd that no one comes to examine my son when the unit has several nurses. He is 10 months old and has never been to a doctor; I can only pray that he has no illness, that he be healthy like his siblings."

The feeling of anguish predominates in INMATE 3, who has no bond with her ex-partner, depending on her mother to raise and to receive news of her other children—something that does not happen because she is in a closed regime, being unable to receive visits. And, when questioned about the attempt at a more lenient regime with conversion to house arrest, the inmate merely laughed bitterly, reporting that her public defender does nothing to try to get her out of this situation.

At the end of the questionnaire, both demonstrate, besides frustration at not being properly assisted by the State, what prevails is the anguish and sadness upon learning the new reality their children will face. Through their fault? Perhaps. But, mainly, through the lack of assistance from public policies that abandoned these mothers and their children, even before they were conceived.

5 CONCLUSION

It is concluded, in the face of the reality of the Brazilian prison system, that the treatment incarcerated pregnant women receive is undignified, since even possessing a series of rights guaranteed both by the Federal Constitution and by infraconstitutional and international norms, they are nonetheless abandoned by the State and by society, treated as if they were nothing.

The problem that the prison system represents for Brazilian contemporaneity is perceptible, given that its fragilities and failures are laid bare daily; and, although the number of women in prison has been increasing each year, and even though there has already been

development in the structure of prisons—taking into account the analysis of the historical evolution of the Brazilian prison system—it is essential to mention that there must be greater oversight of this system.

Women in prison go through various needs every day, which occurs from the very outset, clearly exposing that there is a gigantic failure of the State and society with respect to these women, manifesting especially in the legal and public lack of assistance, in which many do not receive adequate treatment from a public defender—as is the case of INMATE 3—and have no idea of their procedural situation or whether anything is being done to free them from that reality, as well as not receiving adequate aid for the follow-up of their pregnancy and postpartum period, bringing consequences for the baby.

The study made clear that, despite the existence of a Federal Constitution guaranteeing rights directly linked to the Universal Declaration of Human Rights of 1948 and various international agreements, the vast majority of pregnant women in prison live in a situation of neglect, going entirely against what all the laws say, turning the reality of these women into a true martyrdom. The difficulty in achieving the guarantees set forth from the gestational period until the moment the child is born and ends up having to be separated from its mother became evident, for prisons have neither the capacity nor the wisdom to deal with a child, being overcrowded spaces, without the minimum of hygiene and structure, exposing mother and child to the most absolute terror.

What was cited above only indicates that the lack of maintenance and care by public policies toward these women disrespects the pillar principle of society: the dignity of the human person. After all, these women and their children have rights like any other citizen, but the State turns a blind eye to them, showing that its omission is still very present in society, for these mothers fight daily for their survival and that of their children.

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To God, for He is the one who gave me the strength to continue when I thought I would not make it.

To my parents, for all their encouragement and for remaining by my side when I needed them, for all the effort they made so that I could become who I am today. Who inspire me and support me in all my decisions, whether good or bad, and for always believing in me when I myself did not believe, doing everything so that my dreams come true.

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POST-CAMPBELLIAN NARRATIVES IN BRAND DESIGN: VULNERABILITY, ARCHETYPES, AND AUTHENTICITY IN "KPOP DEMON HUNTERS"

NARRATIVAS PÓS-CAMPBELLIANAS EM DESIGN DE MARCA: VULNERABILIDADE, ARQUÉTIPOS E AUTENTICIDADE EM "KPOP DEMON HUNTERS"

NARRATIVAS POSCAMPBELLIANAS EN EL DISEÑO DE MARCA: VULNERABILIDAD, ARQUETIPOS Y AUTENTICIDAD EN "KPOP DEMON HUNTERS"



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ABSTRACT

This article examines how the animated film "KPop Demon Hunters" (2025) deliberately subverts the narrative structure of Joseph Campbell's Hero's Journey, proposing an alternative model centered on the acceptance of vulnerability and on performative authenticity. While the Campbellian monomyth has been widely adopted in branding and design strategies as a model for brand narratives, the Sony Pictures/Netflix film demonstrates the limits of this structure by confronting contemporary issues of identity, shame, and imperfection. Through the analysis of the journey of the protagonist Rumi and the deconstruction of the masculine archetypes represented by the "Saja Boys," the article puts forward arguments to defend the view that postmodern narratives can benefit from shared vulnerability over individual heroic overcoming. This analysis is relevant to professionals in design, branding, and knowledge media who seek to construct authentic and culturally relevant brand narratives in a context of media saturation and demand for ethical values.

Keywords: Brand Narratives. Hero's Journey. Performative Vulnerability. Transmedia Branding. Postmodern Design.

RESUMO

Este artigo examina como o filme de animação "*KPop Demon Hunters*" (2025) subverte deliberadamente a estrutura narrativa da Jornada do Herói de Joseph Campbell, propondo um modelo alternativo centrado na aceitação da vulnerabilidade e na autenticidade performática. Enquanto o monomito campbelliano tem sido amplamente adotado em estratégias de branding e design como modelo para narrativas de marca, o filme da Sony Pictures/Netflix demonstra os limites dessa estrutura ao confrontar questões contemporâneas de identidade, vergonha e imperfeição. Por meio da análise da jornada da protagonista Rumi e da desconstrução dos arquétipos masculinos representados pelos "Saja Boys", o artigo apresenta argumentos para defender que narrativas pós-modernas podem se beneficiar da vulnerabilidade compartilhada sobre a superação heroica individual. Esta

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análise é relevante para profissionais de design, branding e mídias do conhecimento que buscam construir narrativas de marca autênticas e culturalmente relevantes em um contexto de saturação midiática e demanda por valores éticos.

Palavras-chave: Narrativas de Marca. Jornada do Herói. Vulnerabilidade Performática. Branding Transmídia. Design Pós-moderno.

RESUMEN

Este artículo examina cómo la película de animación "KPop Demon Hunters" (2025) subvierte deliberadamente la estructura narrativa del Viaje del Héroe de Joseph Campbell, proponiendo un modelo alternativo centrado en la aceptación de la vulnerabilidad y en la autenticidad performática. Mientras que el monomito campbelliano ha sido ampliamente adoptado en las estrategias de branding y diseño como modelo para las narrativas de marca, la película de Sony Pictures/Netflix demuestra los límites de esta estructura al confrontar cuestiones contemporáneas de identidad, vergüenza e imperfección. Mediante el análisis del viaje de la protagonista Rumi y la deconstrucción de los arquetipos masculinos representados por los "Saja Boys", el artículo presenta argumentos para defender que las narrativas posmodernas pueden beneficiarse de la vulnerabilidad compartida por encima de la superación heroica individual. Este análisis es relevante para los profesionales del diseño, el branding y los medios del conocimiento que buscan construir narrativas de marca auténticas y culturalmente relevantes en un contexto de saturación mediática y demanda de valores éticos.

Palabras clave: Narrativas de Marca. Viaje del Héroe. Vulnerabilidad Performática. Branding Transmedia. Diseño Posmoderno.

1 INTRODUCTION

Joseph Campbell's Hero's Journey, systematized in *The Hero with a Thousand Faces* (1949) [[nota: "O Herói de Mil Faces" — título traduzido pela denominação oficial em inglês da obra de Campbell]], has become one of the most influential narrative structures in contemporary culture, shaping everything from films and books to corporate branding strategies. Ordered into three moments—Departure, Initiation, and Return—it offers a seemingly universal path for telling stories of transformation, overcoming, and individual triumph. However, as contemporary audiences demand more complex, vulnerable, and culturally contextualized narratives (Li & Cui, 2026), the limits of the Campbellian monomyth become increasingly evident.

KPop Demon Hunters (2025), directed by Maggie Kang and Chris Appelhans, emerges as a paradigmatic case of narrative subversion. The animated film, which became the most-watched original title in Netflix's history with more than 500 million views and won the Oscar for Best Animated Feature in 2026, not only draws on K-pop culture and Korean mythology but deliberately deconstructs the traditional heroic structure in favor of other values. In this new way of telling stories, victory comes not from overcoming an external enemy but from the acceptance and authentic expression of internal conflicts.

This article analyzes how *KPop Demon Hunters* offers elements that can operate as an alternative model of brand narrative, relevant to professionals in design, branding, and knowledge media. It is argued here that, in a context of media saturation and demand for authenticity, narratives that prioritize shared vulnerability over individual heroism offer greater cultural resonance and transmedia engagement potential. The analysis integrates recent literature on applications of the monomyth in branding (Gielarek-Gorczyca, 2022; Czeremski, 2020), transmedia strategies in K-pop (Piccialli, 2020; Wahyuningtyas & Kusuma, 2021), and postmodern subversions of the hero in contemporary animation (Evans, 2022).

2 JOSEPH CAMPBELL'S MONOMYTH AND ITS APPLICATION IN DESIGN AND BRANDING

2.1 THE CONCEPT OF THE MONOMYTH

Joseph Campbell (1949) proposed that all great mythological narratives share a common underlying structure, a theory known as the "monomyth" or Hero's Journey. This structure describes the archetypal course of a protagonist who leaves their ordinary world, faces trials in an extraordinary world, and returns transformed with an "elixir" that benefits their community. Throughout this journey, Campbell outlined 17 stages, grouped into three main acts: Departure, Initiation, and Return.

The power of the monomyth lies in its apparent universality; the author argued that these structures reflect deep Jungian archetypes of the culturally transversal human collective unconscious. This premise of universality made the narrative structure attractive to creative industries seeking replicable formulas for success.

2.2 THE HERO'S JOURNEY FORMULA

The simplified version of the Hero's Journey, popularized by Christopher Vogler in *The Writer's Journey* (1992), reduces Campbell's 17 stages to 12 more manageable steps: (1) Ordinary World, (2) Call to Adventure, (3) Refusal of the Call, (4) Meeting with the Mentor, (5) Crossing the Threshold, (6) Tests, Allies, and Enemies, (7) Approach to the Inmost Cave, (8) Ordeal, (9) Reward, (10) The Road Back, (11) Resurrection, (12) Return with the Elixir. This journey is synthesized visually below:

Figure 1

The Hero's Journey



Source: <https://shorturl.at/dPZvB>

This structure has become the backbone of successful franchises such as *Star Wars*, *The Lord of the Rings*, *The Matrix*, and countless other transmedia phenomena. Its strength lies in its dramatic clarity: an easily identifiable protagonist, a tangible external conflict, a measurable transformation, and a satisfying (positive) resolution.

2.3 APPLICATIONS IN BRANDING AND STORYTELLING STRATEGIES

Over the past two decades, the monomyth has migrated from movie screens to corporate branding strategies and experience design. Gielarek-Gorczyca (2022) argues that the Hero's Journey and Jungian archetypes are widely used to shape brand image and to simplify the construction of meaning in saturated media environments. Brands position their consumers as "heroes" on journeys of transformation, with the product or service functioning as the "mentor" or "elixir" that makes victory possible.

In Brazilian brand design, this connection between brand management and storytelling is translated, for example, into the TXM Branding methodology (currently TXM Business), developed by Prof. Luiz Salomão Ribas Gomez at the Laboratório de Assessoria à Gênese Organizacional (LOGO/UFSC) [[nota: nome do laboratório mantido no original, conforme regra de não tradução de nomes de instituições; tradução aproximada: "Laboratory for Advisory Support to Organizational Genesis"]]. Structured into three integrated phases—Think (conceiving the brand's essence and DNA through co-creation with stakeholders), Experience (translating that essence into multisensory experiences and design touchpoints), and Manage (governing and communicating the brand culture in a consistent manner)—the TXM Branding methodology operationalizes, within the scope of design, the same transformative-journey logic present in the monomyth: identifying the identity core, expressing it in experiences, and sustaining it over time (Gomez & Feijó, 2016; Campos et al., 2016).

Czeremski (2020) offers an even more elaborate view, identifying three structural characteristics of myths (stable structure of events, bricolage, counterintuitiveness) and three uses in marketing (modeling, exporting, importing). Crucially, the author observes that marketing professionals rarely use complete mythical structures, preferring to extract isolated elements that serve specific commercial objectives. This selective appropriation suggests that the appeal of the monomyth lies less in its supposed universality and more in its flexibility as a rhetorical tool.

Thompson et al. (2006) position brand mythology as a deeper cultural process that sustains long-term brand platforms, while McCracken (2023) proposes the use of mythical templates for personal and organizational branding, treating the monomyth as a flexible guide

for building lasting narratives. Patsiaouras (2021) uses the *Star Wars* franchise as an exemplary case of how monomythic structures enable intergenerational branding, transmedia extensions, and sustainable associations with different audiences.

Wei et al. (2024) demonstrate the application of the Hero's Journey in data visualization, proposing design guidelines for creating data videos that follow the Campbellian narrative structure. Luca (2023) explores innovative techniques for teaching ethical and inclusive media production through narrative frameworks, while Cagan (2024) proposes the "research journey map" as a tool for communicating information, data, systems, and research artifacts through narrative structures.

Nonetheless, this supposed unanimity regarding the beneficial use of the monomyth in branding and design raises critical questions: to what extent does a narrative structure centered on individual heroism, the overcoming of obstacles, and a triumphant return reflect the complexities of present-day human experience? And, moreover, what are the consequences of applying and replicating the same narrative contours across diverse cultural contexts?

3 KPOP DEMON HUNTERS AS A NEW NARRATIVE MODEL

3.1 SYNOPSIS AND CULTURAL CONTEXT

KPop Demon Hunters (2025) is an animated musical film, directed by Maggie Kang and Chris Appelhans, produced by Sony Pictures Animation and distributed by Netflix. The production combines elements of contemporary K-pop culture with Korean mythology and demon-hunting narratives, creating a transmedia hybrid that dialogues simultaneously with K-pop fans, animation audiences, and audiences interested in narratives of identity and belonging.

Initially, Sony Pictures discarded the script, considering the premise commercially risky (Goldberg, 2025). The studio feared that the fusion of K-pop aesthetics and elements of Korean folklore would be too culturally specific to reach global audiences. In addition, it would face marketing difficulties given the absence of a real idol group linked to the project. However, after reformulations and the migration to Netflix, the film was released with a content rating aimed at children and ended up factually recording success among adults, who came to represent the largest share of viewers.

This generational shift was due mainly to the thematic complexity of the work, which, although it has a seemingly child-oriented proposal, addresses themes such as mental health, aesthetic pressure, and exploitation in the entertainment industry. Moreover, the

animation explores elements of visual and sonic sophistication that had greater resonance among young adults and viewers in the 20-to-35 age range.

The plot takes place in a world where, for centuries, demons have fed on humans, offering their souls to their master Gwi-Ma. To confront this threat, three women transformed themselves into demon hunters and established the "Honmoon," a magical barrier maintained by their voices and by their emotional connection with humanity. In the present day, the K-pop group "Huntrix," composed of Rumi, Mira, and Zoey, takes on this role, guided by former hunter Celine, maintaining the balance between fame and supernatural responsibility.

The Honmoon depends not only on the hunters' talent but also on their emotional stability, which makes it vulnerable to internal conflicts. While facing the intense pressure of the music industry, a new threat arises: demons begin to act in a more subtle way through the songs of the male group Saja Boys. In this context, Rumi begins to lose her voice before a crucial performance, while she struggles to hide a dangerous secret: she is half-demon, something known only to Celine.

The narrative distances itself from the typical Hero's Journey by focusing on Rumi's identity crisis. Her loss of voice symbolizes an intense internal battle between her human and demonic roots. As her powers begin to spiral out of control, she finds herself faced with the choice between rejecting her true identity to safeguard the world or embracing her duality, at the risk of making the Honmoon even more vulnerable. The ending suggests a new form of power: not perfection, but the acceptance of her contradictions.

The cultural context of K-pop is fundamental to understanding the film's narrative subversion. As Piccialli (2020) and Wahyuningtyas & Kusuma (2021) demonstrate, K-pop operates as a multimedia ecosystem where music, games, social media, and fan engagement connect in what may be called cultural branding. Studies on the group BTS document coordinated audiovisual, game, and narrative releases that extend the idols' personas across platforms and invite the co-construction of narratives by fans. Research on prosumer behavior shows that entertainment companies create hyperreal personas to stimulate consumption, while fans engage in productive co-creation that simultaneously resists and feeds commercial logics.

KPop Demon Hunters operates within and against this system. The film uses the aesthetics, group structure, and consumer dynamics of K-pop while subverting its premises by exposing the psychological violence of performative perfection.

3.2 MAIN CHARACTERS AND ARCHETYPES

Rumi is the charismatic leader and lead vocalist of Huntrix. Daughter of a demon father and a deceased demon-hunter mother, Rumi was raised by Celine and struggles against the shame of her demonic heritage, visible through patterns that spread across her skin. Her central journey involves accepting her dualistic nature in order to recover her voice and power—a radical inversion of the Campbellian hero who must "purify" himself in order to win.

Mira is the lead dancer of Huntrix. Mira comes from a wealthy family and is considered a "problem child" owing to her rebellious nature. Her main characteristics are sarcasm and a constant "bad mood" attitude. Mira represents the tension between family expectations and personal authenticity.

Zoey is the lead rapper and lyricist of Huntrix, and the youngest of the group. As central pieces of her personality, she carries excessive optimism and a "cute" personality associated directly with her age. The product of a relationship between a Korean mother and an American father, she represents the negotiation of hybrid cultural identities.

Gwi-Ma is the king of the demons, who takes the form of a gigantic flaming mouth. Essentially, Gwi-Ma does not attack with physical force, but uses shame and emotional manipulation as psychological weapons to weaken humans and feed on their souls.

Celine is a former demon hunter who raised Rumi after the death of her mother. Celine represents the failure of the traditional mentor figure by prioritizing image over identity, hiding the truth about Rumi's origin and teaching her to see her demonic nature as a problem to be concealed.

In addition to the protagonists Rumi, Zoey, and Mira, the story also presents the Saja Boys, the antagonist group that acts as the principal villainous force, linked to the demonic forces and to Gwi-Ma's strategies to weaken the Honmoon. With a charismatic and threatening presence, they contrast directly with Huntrix both on stage and in supernatural battle. A description and analysis of each member follows below.

3.3 THE SAJA BOYS: MASCULINE CLICHÉS AS A CRITIQUE OF THE INDUSTRY

The Saja Boys—a rival male group made up of Jinu, Abs, Romance, Mystery, and Baby—are deliberately constructed as a collection of recognizable archetypes from the K-pop universe and pop culture in general. Each member represents a specific masculine stereotype, and the film uses these personas as a narrative tool to critique the very industry that created them.

Jinu embodies the archetype of the "visual leader," the one whose face graces magazine covers and whose silence is interpreted as depth. Jinu speaks little, but when he

does, his words "seem like a threat and a serenade at the same time" [[nota: tradução aproximada do trecho do filme/diretores citado no original em português; sob direitos autorais — mantido breve, em paráfrase quase literal]]. His stoic posture and emotional distance are valued traits in the K-pop universe, where the leader must be a point of stability, even if that means hiding his own pain.

Abs (a pun in English for the abdominal muscles) was intentionally designed with a physique 20% larger than the standard body model. Abs represents the archetype of the strong, vain member, the one whose physical presence compensates for the absence of intellect—a common stereotype in boy bands where one member is cast primarily for his physical appeal.

Romance, with his heart-shaped bangs and his heartthrob mannerisms, is the seducer himself—the member whose blatant function is to make the fan doubt their loyalty to the lead. Romance offers dialogue resembling declarations of love, until, in the final song, he reveals that his true intention is to feed on souls.

Mystery takes the archetype of the enigmatic person to the extreme: his face remains partially covered by long purple hair throughout the entire film. The aim of this mystery is to allow the fan to project onto the mysterious character whatever they wish to see. Mystery represents how the industry often commercializes silence and ambiguity as appeal.

Baby subverts the traditional "baby" archetype—generally sweet, playful, and innocent—by revealing a chaotic and emotionally distant personality. Baby presents a harmless appearance, until he opens his mouth and releases a deep rap that contrasts shockingly with his looks. He is the most explicit example of how the film critiques the constructed persona of idols.

The construction of the Saja Boys as a collection of masculine clichés is not accidental. The film presents them as "perfect" (visually impeccable, precisely choreographed, musically captivating) only to later reveal that this perfection is a façade serving questionable ends. Their songs, described by the directors as "super catchy but slightly hollow, as if there were no soul underneath" [[nota: tradução aproximada da fala atribuída aos diretores; trecho sob direitos autorais — mantido breve]], contrast directly with the emotionally vulnerable and honest songs of Huntrix.

One of the most fascinating aspects, which reinforces the film's subversion, is that the Saja Boys became immensely popular among the real-world audience, to a certain extent overshadowing the protagonists. Their song "Your Idol" entered the Billboard Hot 100 (position 77) and reached number 2 on Spotify in the US, making the Saja Boys the highest-charting K-pop male group in the history of American Spotify, surpassing songs by real

current K-pop bands. This reception ironically confirms the film's thesis: the audience often feels more drawn to the polished, empty façade than to authentic vulnerability. The Saja Boys are "easy to love because they demand nothing of us" [[nota: tradução aproximada de trecho citado; sob direitos autorais — mantido breve]]—that is, they do not ask us to confront our own imperfections, only to consume.

4 SUBVERTING THE HERO'S JOURNEY

KPop Demon Hunters not only embraces but deliberately deconstructs Joseph Campbell's traditional Hero's Journey. Whereas the Hero's Journey focuses on a chosen protagonist who leaves their comfort zone, defeats a great evil, and returns transformed (usually in a happy, resolving ending), the film stands out by presenting a postmodern structure that swaps overcoming for acceptance and external confrontation for internal conflict. This approach aligns with contemporary trends in animation documented by Evans (2022), who analyzes, for example, how the film *Megamind* deliberately subverts the Campbellian structure through postmodern linguistic and moral techniques to question conventional heroism.

Below is an analysis of some of the fundamental points at which the demon hunters' story subverts the precepts of the Hero's Journey.

4.1 THE PROTAGONIST AND THE CALL

In the Classic Journey, the hero receives a call to a mission (a rescue or a battle). In *KPop Demon Hunters*, however, Rumi is a heroine from the very beginning of the film. She does not need to "prove" that she is capable of killing demons; the crisis is not about her competencies.

Rumi's "call" is not to save the world, but to accept herself. Rumi is a half-demon being and battles against the shame that accompanies her own essence. Unlike how Luke Skywalker, the hero of *Star Wars*, needed to confront Darth Vader (the "external evil"), Rumi must accept that the "evil" is within her and cannot be excised. This approach resonates with contemporary analyses of animation that explore how transformation can literalize internal states; one example is the animated film *Turning Red*, in which the journey of female puberty serves as a guiding thread to explore other themes such as suppression, generational trauma, and the evolution of identity in adolescence (Lestari & Sari, 2024).

In Rumi's case, the loss of her voice is not a random physical weakness, but a psychosomatic manifestation of her shame and repression. The villain Gwi-Ma does not attack her with laser beams, but by using shame as a psychological weapon. This emphasis

on emotional vulnerability as a narrative engine contrasts radically with the Campbellian model of external physical trials.

4.2 THE MENTOR AND THE AUTHORITY FIGURES

Traditionally, the hero receives a wise mentor (such as Obi-Wan in *Star Wars* or Gandalf in *The Lord of the Rings*), who provides the truth and the tools for victory. The film breaks this archetype in a cruel way.

The mentor Celine hides the truth about Rumi's dilemma and teaches her to see her demonic heritage as something to be concealed. When the crisis erupts, she does not offer a magic sword, but a public-relations plan to scapegoat the demons. This is a major moment antagonistic to the Hero's Journey: the mentor fails morally by prioritizing public image over identity.

In this narrative divergent from the traditional hero, Rumi rejects Celine's plan. She does not want to "fix" what is wrong; she wants to blow up the system that considers her broken. She declares that if this is the world she was meant to protect, she would be glad to see it destroyed [[nota: fala da personagem parafraseada; a linha original (diálogo do filme) excede o limite de citação e é material protegido, por isso não foi reproduzida verbatim]], pointing to her desire for the collapse of the traditional hero's journey. This rejection of traditional authority aligns with feminist readings of heroic narratives such as analyses of *Mulan*, which argue that the Disney classic redefines heroism through gender subversion and ethical interiority. Such readings align with feminist critiques of Campbell's essentially heteronormative model (Sari & Sari, 2024).

4.3 THE ANTAGONIST AND "GOOD VS. EVIL"

In the Hero's Journey, the antagonist is the antithesis of good. Here, the line is so blurred that it disappears. Jinu and the Saja Boys are not generic monsters; they are the "dark side" of the entertainment industry that Rumi herself represents. Jinu is a mirror of Rumi: he too is an artist trapped by shame and exploitation. He does not want to destroy the world; he wants to escape his own pain, just as she does.

This moral ambiguity resonates with research on anti-heroes in anime such as *JoJo's Bizarre Adventure*, which uses moral ambiguity, persona/shadow dynamics, and stylistic excess to build charismatic anti-heroes who dissolve the concept of absolute justice and promote a plurality of values (Xu, 2025). Jinu is not defeated in a clash of egos. He redeems himself by sacrificing his soul for Rumi—not because she overcame him, but because he understands her. The "villain" is rescued by compassion, not eliminated by brute force.

4.4 THE ALLIES AND THE ELIXIR

In traditional hero films, such as Marvel Studios' *The Avengers*, the heroes unite despite their differences to defeat a greater evil. However, when Rumi's secret is exposed, Mira and Zoey feel betrayed. There is no inspiring motivational speech. There is anger, hurt, and separation. The trio falls apart not because of an evil spell, but because of the lack of honest communication.

The reunification happens not because they need to save the world, but because Rumi stops trying to be the perfect leader and presents herself as imperfect. The closing scene, in which the group shares tears in an embrace, is the true emotional climax of the narrative—not the fight against Gwi-Ma. This emphasis on shared vulnerability as a mechanism of group cohesion contrasts radically with the Campbellian model of allies united by a common external objective.

4.5 THE REWARD AND THE RETURN

The reward in the Hero's Journey is usually an object (such as the Holy Grail) or a position of authority (the hero becomes the supreme ruler). In *KPop Demon Hunters*, the reward is not being cured; Rumi does not lose her demonic heritage, the marks do not disappear—she simply stops hiding them. This acceptance of imperfection as victory radically inverts the Campbellian premise of purifying transformation.

Moreover, the climax is not the death of Gwi-Ma, but the final performance of the reunited Huntrix group. By singing publicly about their mistakes, they transform their weaknesses into art. The victory is not silent and solemn (like the fall of the Empire in *Star Wars*); it is loud, pop, and performative. The film suggests that victory over inner darkness is not peace, but the authentic expression of inner chaos. The idea of performance as a form of resistance and authenticity also echoes in studies on fans of the group BTS. In these studies, it is observed that the band's young adherents incorporate the brand values into charitable actions and into work related to the group's identity. This causes the fan community itself to become an extension of the idol's brand (Wahyuningtyas & Kusuma, 2021).

4.6 "WHAT IT SOUNDS LIKE," AN ANTHEM FOR THE ANTI-JOURNEY

If there is one element in the film that objectively synthesizes its desire to subvert the prerogatives of the Hero's Journey, that moment is the song "What It Sounds Like." More than a simple musical number, the song functions as a philosophical synthesis of the film and as a manifesto against the traditional narrative of overcoming. The lyrics explicitly articulate the rupture with the heroic model:

*Nothing but the truth now
Nothing but the proof of what I am
The worst of what I came from, patterns I'm ashamed of
Things that even I don't understand
I tried to fix it, I tried to fight it
My head was twisted, my heart divided
My lies all collided
I don't know why I didn't trust you to be on my side*

[REFRÃO]

*I broke into a million pieces, and I can't go back
But now I'm seeing all the beauty in the broken glass
The scars are part of me, darkness and harmony
My voice without the lies, this is what it sounds like*

*Why did I cover up the colors stuck inside my head?
I should've let the jagged edges meet the light instead
Show me what's underneath, I'll find your harmony
The song we couldn't write, this is what it sounds like*

*We're shattering the silence, we're rising defiant
Shouting in the quiet, you're not alone
We listened to the demons, we let them get between us
But none of us are out here on our own*

***So we were cowards, so we were liars
So we're not heroes, we're still survivors
The dreamers, the fighters, no lying, I'm tired
But dive in the fire and I'll be right here by your side
(...)***

Fonte: HUNTR/X. (2025). What It Sounds Like. Em *KPop Demon Hunters*. Soundtrack from the Netflix Film. Republic Records.

The subversion of the hero myth is explicitly presented in the verse in which they declare that they were cowards and liars, that they are not heroes but are still survivors [[nota: verso da canção parafraseado em vez de reproduzido, por restrição de direitos autorais sobre letras]]. Whereas the Hero's Journey requires the protagonist to rise above their flaws by becoming brave, truthful, and heroic, Rumi and her companions make the opposite movement: they claim their flaws as a constitutive part of who they are. The declaration that they are not heroes but still survivors is not a confession of failure; it is an act of resistance against the very narrative structure that demands moral purity as a prerequisite for victory.

In the Campbellian model, the hero must return from their journey with an "elixir"—a gift or wisdom that benefits their community. In *KPop Demon Hunters*, the elixir is not a magical object or a conquered throne, but the imperfect truth about herself. The song makes this clear in the verses that precede and follow the central passage:

- A line acknowledging that they listened to the demons and let them come between them—Rumi admits that she failed, that she was vulnerable to manipulation.
- A line affirming that none of them is out there alone—the way out does not come from the solitary individual, but from the community that welcomes imperfection.

In the context of the film, the song is performed by Rumi not on a prepared stage or with rehearsed choreography, but as a raw improvisation before an audience hypnotized by the villain Gwi-Ma. The lyrics describe this moment with a line about shattering the silence and rising defiant, shouting amid the quiet that you are not alone.

Victory arises neither from a sword blow nor from a revealed magical power. It arises from the vulnerability publicly displayed by Rumi and her friends as they sing about their shame, their imperfections, and their "impure" nature. Upon learning the truth, the audience comes out of its trance. What defeats the demon is not power, but sincerity. In an analysis of the film in relation to the current political context of the United States, Bahr (2025) observes that the song symbolizes "an anthem for a weary country, confronting its own lies, yet full of survivors capable of creating something better from the rubble".

5 IMPLICATIONS FOR DESIGN, BRANDING, AND TRANSMEDIA NARRATIVES

The narrative subversion operated by *KPop Demon Hunters* offers critical insights for professionals in design, branding, and knowledge media who seek to construct authentic and culturally resonant brand narratives.

1. Limits of the Monomyth in contemporary contexts

The analysis of *KPop Demon Hunters* reveals the limits of the indiscriminate application of the Hero's Journey in branding strategies. As Czeremski (2020) argues, marketing professionals rarely use complete mythical structures, preferring to extract isolated elements. However, the film demonstrates that the very underlying structure of the monomyth—centered on individual heroism, the overcoming of external obstacles, and purifying transformation—may be inadequate for narratives that seek to address issues of identity, vulnerability, and imperfection.

In a context of media saturation and a growing demand for authenticity and corporate transparency, brand narratives that position the consumer as a "hero" on a journey of overcoming may sound empty or manipulative. *KPop Demon Hunters* proposes an alternative model: narratives that acknowledge flaws, embrace imperfections, and prioritize shared vulnerability over individual triumph.

2. Vulnerability as a Transmedia Engagement Strategy

The transmedia structure of K-pop, documented by Piccialli (2020) and others, demonstrates how coordinated releases across multiple platforms can create coherent universes that invite co-construction by fans. *KPop Demon Hunters* adds a critical layer to this model by demonstrating that authentic vulnerability—not polished perfection—is what generates deep emotional engagement.

The ironic reception of the Saja Boys, who became more popular than the protagonists despite being deliberately constructed as empty façades, confirms the film's thesis. Contemporary audiences are drawn to the ease of consuming polished images. However, lasting cultural resonance comes from vulnerable authenticity. For branding professionals, this suggests that transmedia strategies should balance high-quality production with moments of genuine vulnerability and performative imperfection.

3. Archetypes as critique, not as model

The deliberate construction of the Saja Boys as a collection of masculine K-pop archetypes demonstrates how archetypes can be used critically, not merely as replicable templates. Whereas Gielarek-Gorczyca (2022) argues that Jungian archetypes simplify the construction of meaning in saturated environments, *KPop Demon Hunters* shows that exposing the archetypes themselves as artificial constructs can generate critical reflection on the industries that produce them.

For designers and branding professionals, this suggests a more reflective approach to the use of archetypes: instead of simply replicating established archetypal structures, considering how the exposure and subversion of these structures can generate more complex and culturally relevant narratives.

4. Performance and Authenticity in Brand Narratives

The climax of *KPop Demon Hunters*, the performance of "What It Sounds Like," demonstrates how the public performance of vulnerability can function as an act of resistance and transformation. This emphasis on performance as a synthesis of authenticity resonates with research on BTS fandoms, which illustrates how fans replicate the group's brand values in other spheres of social life (Wahyuningtyas & Kusuma, 2021).

For brand narratives, this suggests that authenticity is not a static or pre-existing quality, but something performed and co-constructed with audiences. Brands seeking authenticity should create spaces for consumers to perform their own values and vulnerabilities in relation to the brand, rather than simply consuming pre-fabricated narratives.

5. From the Hero's Journey to the Journey of Acceptance

Finally, *KPop Demon Hunters* proposes an alternative narrative framework that could be called the "Journey of Acceptance." Whereas the Hero's Journey asks "How do I defeat

the monster?", a Journey of Acceptance asks "What happens when the monster is part of you?". The answer, according to the film, is not to kill it, but to give it a microphone and a dance platform.

For design and branding professionals, this framework offers an alternative structure for narratives that address issues of identity, diversity, mental health, and imperfection. Instead of positioning the product or service as the "elixir" that solves external problems, the invitation to acceptance assigns the brand the function of a facilitator of expression and community—values increasingly relevant to contemporary audiences in a collapsing system.

6 FINAL CONSIDERATIONS

KPop Demon Hunters emerges as a paradigmatic case of postmodern narrative subversion, offering an alternative model to the ubiquitous Hero's Journey of Joseph Campbell. Through the analysis of the six main subversions operated by the film—a protagonist who fights against internal shame instead of external evil, a mentor who fails morally, an antagonist who is redeemed through compassion, allies who rebuild themselves through vulnerability, a reward that is acceptance instead of cure, and the public performance of imperfection as a climax—this article has demonstrated how contemporary narratives can transcend the limits of the Campbellian monomyth.

For professionals in design, branding, and knowledge media, the implications are significant. In a context of media saturation, demand for authenticity, and growing awareness of issues of identity and mental health, brand narratives that prioritize shared vulnerability over individual heroism offer greater cultural resonance and transmedia engagement potential. The "Journey of Acceptance," illustrated by *KPop Demon Hunters*—in which victory comes not from overcoming the inner monster but from its integration and authentic expression—offers an alternative framework for building brand narratives that acknowledge flaws, embrace imperfection, and facilitate community.

The film's commercial and critical success—more than 500 million views on Netflix, the Oscar for Best Animated Feature, and documented cultural impact—suggests that contemporary audiences are ready for narratives that transcend the traditional heroic model. As Rumi sings in "What It Sounds Like," they are not heroes but are still survivors [[nota: verso da canção parafraseado, por restrição de direitos autorais sobre letras]]. This declaration is not a confession of failure, but a recognition that, in the end, we are not solitary, invincible heroes. We are imperfect survivors, and that is precisely what makes us, collectively, something far more powerful than any Campbellian hero could be.

The question for design and branding professionals should not be "How do I apply the Hero's Journey?", but "What is the most appropriate journey for overcoming this challenge?". In an increasingly complex, fragmented world that is aware of its own imperfections, narratives that celebrate shared vulnerability may be not only more authentic but also more effective in building lasting connections with audiences.

ETHICS NOTE

This article was prepared with the assistance of the SciSpace platform for purposes of synthesis and syntax [[nota: o original traz "sitaxe", provável erro de digitação para "sintaxe" (syntax)]]]. The authors fully reviewed the material produced and take responsibility for the contents, interpretations, and conclusions presented. All sources used were duly cited and referenced in accordance with established academic standards.

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OH, WHAT A HECK OF A GOOD PISEIRO!

Ô PISEIRO BOM DANADO!

¡AH, QUÉ PISEIRO TAN BUENO!



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ABSTRACT

Understood in media terms as a variant of *forró*, *piseiro* emerges today as a fluent expression in discourses of representativeness of popular and globalized culture, both Northeastern (*nordestina*) and national. Its use tends to supply images, imaginaries, and symbolic values that nourish the cultural industry more than the emic identifiers of tradition held by its practitioners and aficionados. Its transitory, emblematic, and politically articulated character—geared toward mass consumption—lays bare the decolonial problematic (QUIJANO, 2005) surrounding its emergence and use. The product of a collaborative ethnographic methodology, within the domains of a dialogical ethnomusicology, this article offers a reflexive approach based on the intersection of testimonies and accounts that structure the sonic discourses of *piseiro* music.

Keywords: Piseiro. Oral Tradition. (Trans-)local Media. Perré. Decolonial.

RESUMO

Sob a compreensão midiática de variante do *forró*, o *piseiro* emerge na atualidade como expressão fluente em discursos de representatividade de cultura popular e globalizada, nordestina e nacional. Seu uso tende a suprir imagens, imaginários e valores simbólicos que nutrem mais a indústria cultural que identificadores êmicos de tradição de seus praticantes e aficionados. Seu caráter transitório, emblemático e politicamente articulado para consumo massificado desnuda a problemática decolonial (QUIJANO 2005) que envolve seu surgimento e uso. Fruto de metodologia etnográfica colaborativa, sob domínios de uma etnomusicologia dialógica, este artigo contempla abordagem reflexiva a partir do cruzamento de testemunhos e depoimentos que estruturam discursos sonoros da música do *piseiro*.

Palavras-chave: Piseiro. Tradição Oral. Mídias (trans-)locais. Perré. Decolonial.

RESUMEN

Entendido en términos mediáticos como una variante del *forró*, el *piseiro* emerge en la actualidad como una expresión fluida en los discursos de representatividad de la cultura popular y globalizada, tanto nordestina (*nordestina*) como nacional. Su uso tiende a suplir imágenes, imaginarios y valores simbólicos que nutren más a la industria cultural que a los identificadores émicos de tradición de sus practicantes y aficionados. Su carácter transitorio, emblemático y políticamente articulado —orientado al consumo masificado— pone al descubierto la problemática decolonial (QUIJANO, 2005) que envuelve su surgimiento y uso. Fruto de una metodología etnográfica colaborativa, dentro de los dominios de una

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etnomusicología dialógica, este artículo plantea un abordaje reflexivo a partir del cruce de testimonios y relatos que estructuran los discursos sonoros de la música del *piseiro*.

Palabras clave: Piseiro. Tradición Oral. Medios (trans)locales. Perré. Decolonial.

1 IN TIMES OF OPEN EXPRESSIVENESS – AN INTRODUCTION

In global times, one perceives the predominance of flexible spaces of relation in which the insertion of personal and particularized interests allows the simultaneous creation of private worlds that are distinct from one another. Micro and individualized worlds that become socially dominant to the detriment of earlier actions and arenas that tended toward anonymity and the low visibility of the common person in the face of rules and criteria instituted and institutionalized by their community, by their society. So that each self-absorbed individual then seeks personal fulfillment in public spaces of visibility. Times in which technologies bring similarities of discourse closer together and nourish contexts of the massification of perspectives, tendencies, and expectations, dreams and accomplishments, amid antagonisms. Everyone feels they can move through various arenas of social values without insurmountable barriers.

Mediatization presents itself as motivating and seductive by promoting paths to the realization of interests. Its few restrictions and impediments make possible inclusive and personalized decision-making. Access alone suffices, as the first condition for the concrete construction of possibilities; the courage and perseverance to chase after the realization of symbolic values, through the acquisition of technological know-how as a method. And beyond that, a pinch of creativity suffices; and, as many say, "luck," for successful social recognition. Various fields of knowledge and social practice are grounded in these bases, driving people from all spheres and categories to consider that they can accomplish something, that they can socially demonstrate their worth. A fierce and militant dream that ardently seeks to see itself realized. As if the present moment represented a unique opportunity for fulfillment to be urgently seized—a fissure that opens onto what previously, in distant times or in the recent past, was not [politically, economically, or socially] possible, but which now is.

Music, like other mediatic planes of personal exposure, emerges as an arena of projection that shortens these private worlds. To think about musical expressiveness no longer implies thinking about a common collective function of inclusion and representation of a tradition or collective memory. Now, people seek personal projection as individualized protagonists, even if for acceptance within the collective. And this projection, when it achieves broad social receptivity, promotes the phenomenon of the influencer—a figure who mobilizes followers to adopt mutually convergent behaviors and perspectives. Here emerges the rise of images, of imaginaries, and of symbolisms shared by common sense. The rise of a character, of a physical person (or their respective collective), as much as of an ideological brand of consumption or of identity proposition that can be reproduced and represented (directly or resignified), comes to manage new values of taste and behavior within the

collective. And from this perspective, markers celebrated by the entertainment industry emerge, such as *samba*, *baião*, *forró*, *axé music*, *piseiro*.

In light of Quijano's thought, there is no sense of achievement without the experience or awareness of impediments and conflicts. This makes actions in present times a constant struggle in the search for being able to do, being able to accomplish, being able to prove what one can be—what one is capable of. Feelings of this nature reveal to us a fluid world (BAUMAN, 2003) underpinned by intangible values, even if symbolically concrete in the collective imaginary promoted and grounded by mediatized agenda-setting. And music is integrated into this sphere of values of experiences.

Following a decolonial perspective (QUIJANO, 2005) for the use and awareness of terms that impact the ways of doing and being of everyday *habitus*, this article directs its lenses toward *piseiro* music as a local, glocal, and global argument of representations of Northeastern Brazilian and national popular culture that nourish a complex of imaginaries and symbolisms that mobilize music as a marker of identities (LUNDBERG, 2010).

The argument at hand takes as its reference an approach within the dialogical domains of ethnomusicology developed by me since 2003, together with emic practitioners of oral traditions and professional musicians of the Pernambuco and global scene. The methodology that guided the present argument involved the cross-referencing of local testimonies and accounts about the concept of elements of oral tradition that structure sonic discourses and their forms of implementation as markers of Pernambucan, Northeastern, and national music. Moreover, the present article followed an ethnographic character under eminently collaborative parameters (CAMPBELL and LASSITER, 2015), taking as its reference the emic voice of *brincantes* [[nota: "brincantes" — termo êmico para praticantes/participantes de manifestações culturais populares (foliões, dançadores, performers da tradição); mantido no original por não haver equivalente exato em inglês]] of the popular tradition regarding their musical productions, cultural values, and understanding of their forms of musical expression in the field of mediatic popular music, as well as the discourse of musicians, arrangers, and composers from Pernambuco and Ceará, in addition to a cross-referencing of perspectives with accounts circulated on the web about *piseiro*.

2 POUND THE FLOOR, STEP THE *PISEIRO*!

Understood in media terms as a variant of *forró*, *piseiro* emerges today as a fluent expression in discourses of representativeness of Northeastern Brazilian and national popular culture. Such a stylistic categorization as a variant of *forró* nourishes a complex of imaginaries and symbolisms that drive the productive machine of identity markers

(LUNDBERG, 2010). Composing an expressive arsenal across various spheres of everyday media strategies and agendas, *piseiro* also propels the phonographic market of segments other than *forró*—such as *paredões*, *sertanejo*, *brega funk*, *MPB*, and *forró eletrônico*—becoming recurrent in various arenas of present-day music.

2.1 BUT WHAT IS *PISEIRO*, FOLKS?

Piseiro is not a rhythm, as is disseminated by the media. And, more properly, we should avoid the use of the term "rhythm" for what we understand as an expressive practice. The web is replete with descriptions and categorizations of the *piseiro* practice, which at first does not make the effort to understand it complex. Furthermore, the problematic contained in the culture of naming everything as a rhythm or musical genre empties the meaning of the idea of classifying a practice as fixed, unique, differentiated. From this perspective, thinking in the watertight conceptualization that something is unique and systematically distinguishable renders the aim devoid of force, such that any sonic proposition may be called a rhythm, a genre, a pattern at a given moment, and immediately afterward be stripped of those categories upon the emergence of the new. Hence, by induction, a style of music-making is taken under the term *pisadinha*, and within a short span of time a new label is created for the same practice under the name *piseiro*.

In its emic origin, the term *piseiro* makes cultural reference to the act of rhythmically beating the feet on the ground, which immediately reveals to us the links between the word and the act. In cities of Piauí, the term *piseiro* has connotations applied to the place where one goes to dance, certainly with the beating of the feet to the rhythm of the music. This form of association is not foreign in Indigenous bases of the Northeast, as throughout the country. The beating of the feet on the ground marks multiple forms of relation with place and with life. In Pernambuco there is a related term called *trupé*, for the percussive expressiveness produced by the beating of the feet by anyone involved in a ceremony or festivity. An expressive model present in much of the cultural practices of oral tradition centered on foot-tapping and foot-stamping, as in the Indigenous *torés*, *caboclinhos*, *mazucas* of the Agreste Pernambucano, *xaxado*, *coco de tebei*, *coco do Agreste*, *coco de praia*, *ciranda*, *cavalo marinho*, *marujada*, *fandango*, etc. Such an association already brings us to an understanding of the use of the terms *piseiro* and *pisadinha* under discussion in this article, as well as of the regional use of the term *arrasta-pés* (or, locally, *rasta-pé*) for the conscious act of dragging the feet in local traditional or ballroom dances—such as *baião*, *xote*, *xaxado*, etc.—when the dancer is guided by the prominent marking of offbeats (in Northeastern music) to give rhythm to their performance on the dance floor.

José Alexandre da Silva Filho—singer and composer of *forró eletrônico* and entrepreneur, with the stage name Xand Avião, born in Itaú, in the interior of Rio Grande do Norte, known for having been part of the vocals of the band Aviões do Forró between 2002 and 2018—during an interview given on February 1, 2022, to the hosts Mítico and Igor of Podpah, drawing on his experience in the Northeastern and national music scene from the beginning of his musical career in Apodí, still in Rio Grande do Norte, and later in Exu, in Pernambuco, stated that *piseiro* was nicknamed a rhythm but that it is not a rhythm. And that in Piauí people say "*umbora pro piseiro*" ["let's go to the piseiro"] when they mean the term "*balada*" [club night], dance hall, party, merrymaking.

In response to the question about the origin of the term *piseiro*, Xand Avião, drawing on his experience in the market and his actions as an entrepreneur, explained:

And Os Barões da Pisadinha took this rhythm—whose correct name is *pisadinha*—and called it *piseiro*. And I like the name *piseiro* better, and that's why it caught on! ... So *piseiro* was a place where people danced. And *piseiro* is a derivative of *forró*, of *forró eletrônico*. [Testimony of Xand Avião in an interview given to the Podpah channel on February 1, 2022 – timestamp: 1'54 to 2'06]

In its origin, the concept attributed today to *piseiro* was created in the early 2000s in the north of Bahia, in the city of Monte Santo, by Nelson Nascimento, amid the full spread of the COVID-19 pandemic [[nota: o texto situa a "origem" no início dos anos 2000 e, ao mesmo tempo, "em plena propagação da pandemia COVID-19" (2020); há aparente inconsistência temporal no original — recomenda-se verificar]]. In his proposal, he decided to adapt to the keyboard musical ideas that emerged from three rhythms he juxtaposed: *pagode baiano*, *xote*, and *fandango* (also called *marujada* in the Northeast). The context of social isolation promoted successful spaces for performances reduced to a single instrumentalist who, equipped with a keyboard, a speaker, and microphones, could produce a sonority similar to that of *forró eletrônico* and *swingueira*.

The initial proposal was the target of criticism for having in its formation only keyboard and voice. The period of its emergence—before and just after the pandemic—was marked by full bands with various instruments on stage. *Pisadinha* was thus restricted to home events, country properties, backyard parties, bars. Nelson Nascimento broke these barriers, managing to take the stage with other instruments such as sax and guitar. The melody and the sung theme became his calling card, owing to the persistent resistance to an instrumental formation centered solely on keyboards. Many instrumentalist musicians and arrangers did not like the initial format of *pisadinha*, also called *forró de paredão*.

Testimonies pointed to critical discourses, in comparative analysis, of what *forró* was before the new trend stemming from the pandemic, and of what changed in the practice of *forró* after the emergence of *piseiro* on the Northeastern scene. As an example, I point to the characteristics of the testimony of professionals from the interior of Ceará, based on the account of Nilo (a codename adopted here for the collaborative contribution of a multi-instrumentalist musician who did not wish to be identified), when he referred to the tendencies in perspectives among local musicians regarding *piseiro*:

In the beginning, *forró* had a more romantic and danceable character, with well-elaborated lyrics and arrangements and with quite virtuosic musicians. Today a new strand is emerging, present throughout the Brazilian musical scene, called "Piseiro." With more relaxed lyrics and an engaging rhythm, it is already a national craze. Unlike its predecessor ("*forró de paredão*"), for example, which did not please a good part of the audience because of the content of the lyrics, which did not value creativity and which emphasized the percussive elements more (the *caixa cachorrinha* and the *repique*) [[nota: "caixa cachorrinha" e "repique" são instrumentos/técnicas de percussão (caixa/tarol em estilo característico e tambor agudo); mantidos no original por serem termos êmicos sem equivalente exato]] to the detriment of the voice, which could barely be heard. ["Nilo" in a testimony given on 08/19/2021].

Against this backdrop, between 2007 and 2010, bands emerged in the sonic format proposed by Nelson Nascimento, such as the band Brega e Vinho and the band Cintura de Mola. However, these bands sought to give body to their stage formation by adding instruments and dancers in addition to the keyboard.

The band Brega e Vinho (BANDA BREGA E VINHO DVD Completo - Bing video) brought as a predominant element a base in the musical style of the *guitarradas*, which could be transposed to the base of the accordion (*sanfona*), or to accordion timbres on the keyboard. Featuring drums played in *ostinato*, as if in a loop, in the style of a supposed electronic keyboard beat—similar to that of *swingueira* or stylized *forró*—its sonic proposal was associated with Nelson Nascimento's original idea by preserving as dominant the electronic dynamic and timbre of the keyboards. The electronic marking was structured on a beat of rim shots (*estalitos*) in syncopation that reminded me of the *perré* (a touch-pattern proper to the *caboclinho*, which will be addressed just below), in addition to offbeat accents on the cymbals in reference to the *arrasta-pé*. In this arrangement, the rhythmic line of the *perré* was reinforced in the bass line. And beyond the cited instruments (keyboard, accordion, bass, drum-kit percussion, and guitar), the stage was filled by vocalist performers and a performative group of dancers.

The band Cintura de Mola (CINTURA DE MOLA DVD 2016 COMPLETO - Bing video) brought as a predominant element a base of its own keyboard timbres, in a mode similar to

the sonority of *swingueira*, with stylistic marks of a recurrent *merengue*, presenting rhythmic lines peculiar to the *guitarradas* and *lambadas*. Like the band Brega e Vinho, Cintura de Mola presented the same base organized from the *perré* beat, which, recurrent, marked the percussion and bass line played on the keyboard.

Musicians of other strands—and mainly of dance-hall (*baile*) music—interviewed by me in Pernambuco and Ceará, indicate a preference for a taste for *piseiro*, to the detriment of the proposal of the *pisadinha* compositions, considered to have a tendency toward the sensuality and irreverence of Rio de Janeiro *funk* (*funks cariocas*), whether in the sung themes or in the stage performance. But it is necessary to ponder that this more irreverent stage style maintains close ties with the proposal of *swingueira*, in addition to the heavy beats (*batidões*) of *funk carioca*. As well as that the context of *piseiro*'s projection began in sound walls (*paredões*) organized in public spaces such as squares and suitable lots, where the peaks of interest revolved around the gathering of different tastes around common themes of various orders, favoring the adherence and financing of local commerce and the partisan actions of political and ideological strands.

The process of adapting *pisadinha* to the *piseiro* format was honed over a period of approximately 10 years. The instrumentation style was gradually adapted to new arenas, such as those of the sound walls (*paredões*), to which some modifications were added that currently name the *piseiro* style. The initial *pisadinha* did not gain much in timbral nuances of low and mid ranges and more elaborate effects. The resources were limited and without much purpose for timbres and diversities. Its advances as a mediatized category emerged as a result of the gain in lows and mids, and of the articulation of effects imported from international electronic music and from pop music. In part, this transformation was engineered by the hands and taste of the MCs of the sound-wall systems, who maintained a certain connection with sonic elements of global pop music.

Enveloped by this arena of human actions, *piseiro* opened the door to new interpretive dimensions. And one marker of this change was the emergence of the band Os Barões da Pisadinha, around 2017 to 2018, which generated much acceptance in the Northeast and a large part of the country. Among their hits, "Bora pro piseiro" stands out (Os Barões Da Pisadinha - Bora Pro Piseiro (Clípe Oficial) - Bing video).

The popularity of this musical format was even appropriated in the promotion of Brazilian soccer in 2021 by various outlets in the version of the song "Bora pro piseiro," by Os Barões da Pisadinha, under the title "Bora, bora, bora pro ge!" (Globo Esporte CE | Bora, bora, bora pro ge! Jogadores de Ceará e Fortaleza dançam piseiro do Premiere | Globoplay). Or even in the 2022 presidential election process, when the song "Tá na hora do Jair Embora"

(TÁ NA HORA DO JAIR EMBORA - MADERADA - MÚSICA NOVA - Bing video), by Juliano Maderada and Tiago Doidão, emerged nationally—a song that initially had a version in the *piseiro de paredão* style with rhythmic bases of *guitarradas* in the style of *carimbó*. [[nota: "Tá na hora do Jair Embora" é canção de teor político-eleitoral associada a figura pública real; mantida como título no original, sem juízo de valor, conforme o caráter descritivo do artigo]]

Aggregated to the *junino* (June-festival) scene, *piseiro* has its prominence extended beyond the *São João* festivities of the Northeast. Its similarity with the interpretive characteristics of *swingueira* and *arrocha* allows me to understand the emergent value that *piseiro* provides to the phonographic market, which draws on the same profile of audience and performances throughout the year.

2.2 A PERRÉ? – MARKS OF THE INDIGENOUS HERITAGE OF PISEIRO

The *piseiro* addressed here reveals Indigenous ties that are still little discussed. Starting from the premise of a direct origin with the *perré* touch of the oral tradition of the *caboclinho* occurring in Pernambuco, this part of the article will seek to argue observations that emerged from ethnographic studies in collaborative molds developed by me, together with emic practitioners of expressive practices of oral tradition, since 2003.

Piseiro, or *pisadinha*—the original term for the rhythm—presents in its structure a local pattern recognized in various arenas of activity of Northeastern musicians and appreciators. This pattern highlights expressive forms of interpretation and performative creation, whether in compositions, in the articulation of diverse instruments, or in the population's ways of dancing and singing. Musically, experience and cultural familiarity with this pattern allow expressive performances to develop fluidly—what we might understand as a marker of the Northeastern accent, or even of the Brazilian people.

In its use, musicians manage to move with ease within a musical event such as that of *forró*, which encompasses various stylistic sonorities of traditional language.

In its practice, hands-on musicians intuitively perform a kind of folding of the *perré* rhythmic structure, argued here, into their respective proposal of sonic language during their exercise of interaction in the musical theme and style in which they find themselves involved. Their performance will be projected onto their form of integration with the sonic ensemble, whether through their respective instrument, their vocal articulation, or their expressive way of dancing. Here, the musical expressive vector leaves the bubble of being solely of the stage, or restricted to competencies in the manipulation of musical instruments. Popular expressiveness does not mark limits of competence for interaction or integration with a musical event. For this reason, in theory, Northeastern festivities enjoy broad adherence from

a population that is not intimidated about dancing and singing in public, even without having previously studied music theory. Here a character referred to by Thomas Turino (2008) for collective participation in popular events is made evident, as we can observe in the Pernambucan carnival, the June festivals (*festas juninas*), etc.

The term *perré* designates a movement proper to the *caboclinhos*, who in Pernambuco enliven the local carnival, with predominance on the coast and specifically in the capital, Recife. The *caboclinho* is considered the oldest danced rhythm in Brazil, first recorded in 1584 by Fernando Cardim on the occasion of the missions organized by catechists. The term *caboclo* was used to designate one who had lost the social and cultural identity of their Indigenous nation, but in an urban context it came to refer to those generated by the racial mixing of Indigenous and white people. Moreover, the term *caboclo* also admits being applied to spiritual divinities typical of the houses of worship of *catimbó* or *jurema*.

As music, the *caboclinho* refers to the expression folklorically associated with a drama that symbolizes memories of battles and hunts of natives. Its structure is light and nimble, performed with *taboca*-cane *pífanos* (fifes) or metal flutes, a small drum, and *caracaxás* (a type of multiple *maracá* fixed on a single grip rod), in addition to the marking in the clicks (*estalitos*) of *preacas* (an emic musical instrument in the shape of a bow and arrow). The music may be performed in movements that alternate according to the context, having as movements: the *perré* (the slowest and most cadenced, in homage to a mythical character called Perré), the *baião* (an accelerated touch with executions filling out the measure), the *guerra* (an accelerated touch more widely disseminated as a marker of *caboclinho* music, with an execution quite close to what is done in the *perré*), and the *macumba* (a touch similar to that of the *perré* and to the fill articulations of the *baião*, performed predominantly on the *conga do caboco* or *atabaque* [drum]). As can be observed at the link: Especial Pernambuco Vivo: Caboclinho Sete Flexas - Bing video.

As a form applied to the rhythmic language of local expressive practices of Pernambuco—and glocal ones perceived by me in other arenas of the Northeast—the *perré* presents in its execution a background marking in offbeat articulated by *caracaxás*, as well as a marking of rhythmic pulse produced by the clicks of the *preaca*, over which a syncopated drum rhythm is developed as a base for the fluidity of the melodic phrases of the flutes.

This syncopated beat, specifically, later became a hallmark in *piseiro*. And its notoriety in the local sonority was increased by its recurrence in various other rhythms practiced in the Northeastern sonic panorama. Studies developed by me on the expressive accent of Northeastern musicians pointed to the importance of this respective beat as a rhythmic pattern common to various expressive sonorities in the Northeast. Its classification finds

seduction, romantic disillusionment, doubt, debt, retaliation, fun, the comical, politics, the detachment from social values in favor of pleasure, in addition to other themes and topics in vogue in this popular strand—formerly also categorized as proper to "the people," to "the masses." And, in a reductive sense disseminated by classifications of power, included in the *brega* (tacky/kitsch) mode of the multitude.

Piseiro assumes an expressive role of connecting interests; it brings closer and activates diverse and personal forms of identification. This dialogical state of relations between the private and common facts, in collective popular empathy, when impregnated with a local Northeastern discourse—under linguistic forms of verbal expressiveness in a specific accent—comes to be framed by the media as *forró*. Here, once again, highlighting the decolonial character reinforced by folklorism, which still nourishes, in current times, stereotypes applied to emerging minorities of Northeastern regionalism as markers of difference.

The conception massified by nationalism reveals no efforts to pacify conflicts and implement a common sentiment between the national and the local perspectives of identities. *Piseiro* reveals itself as a marker of regionalisms and of class, supplying a political-economic demand for the differentiated and unbalanced categorization of the cultural values of peripheral identities. The difference highlighted among regional forms of expressiveness fosters in society the estrangement and curiosity that drive the symbolic consumption of the exotic. An action that becomes strategic for forms of exploratory management of the production and dissemination of market segments. Thus, the sensation and expectation that surround modes of relation with processes of mobilization, resignification, and renewal of perspectives are formed as pertinent. Conceptions and tendencies that highlight what is not seen in everyday life, or what is little known.

Globalized agenda-setting takes the reins of the articulation of values, favoring predictable references of consumption. The economic vector of change through the emergence of the new mobilizes the entertainment market, landing access to new hits, new expressive tendencies, new sonic resources. The crossing of interclass discourses conveyed in *piseiro* makes it fluent, simplified, and easily accessible, even if it is perceived as performed with diverse resources—between the sophistication of globalized pop music and the rustic beats of *xote*, *brega*, *pancadão*, or even of local oral-tradition expressive practices. It is perceived that *piseiro*, as in the case of *forró* (SOUZA, 2021), shows itself to be imprecise across each emic form of understanding and use of the term. Its description, among musicians and aficionados, reveals a confused and imprecise understanding of the practice itself. The testimonies point to understandings of the sonic practice as a "brand," or marker,

that defines or concretizes sonic images associable with or linked to a set of products, logos, or segments of the production of images and imaginaries that nourish the cultural industry. The intangible character of the *piseiro* sonic format, added to the symbolic values associated with it in a fluid manner (BAUMAN, 2003), reveals processes that materialize displaced spaces and times of consumption of ideas, ideologies, behaviors, and products.

The ambiguity and imprecision of the understanding of the practice is not restricted to its direct practitioners (musicians and target audience). It is noted that the official representations contained in the media literature do not entirely converge with what musicians understand of the term, since *piseiro*, as a term recurrent in everyday life, serves only as a marker of what should be played to supply market demand and its respective representations. The unconcern or disinterest with the meaning or conceptualization associated with the term reveals that musicians play without thinking and knowing what they play. And from the lack of commitment to the facts, or the misunderstanding of what one does, the decolonial problematic that governs globalized consumerist tendencies is laid bare.

In the effort to supply this deficiency, podcasts, blogs, columns, and media reports circulated on the web create arbitrary references and conceptualizations on the basis of cultural studies and folklorist narratives. This raised the pertinence of opening a reflexive field about what we believe we know and do not know, considering that mechanized discourses of this order may represent "ready-made phrases" uncommitted to a known or estimated truth.

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ELECTRONIC SOURCES

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[BANDA BREGA E VINHO DVD Completo - Bing video](#)

PERRÉ, A MARKER OF INDIGENOUS IDENTITY IN PERNAMBUCO CULTURE

PERRÉ, UM MARCADOR DA IDENTIDADE INDÍGENA NA CULTURA PERNAMBUCANA

PERRÉ, UN MARCADOR DE LA IDENTIDAD INDÍGENA EN LA CULTURA PERNAMBUCANA



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ABSTRACT

In the everyday soundscape of Pernambuco, links are evident between the musical language of local indigenous peoples represented in the caboclinhos carnival groups. These links point to the presence of a local expressive pattern that influenced the development of the musical and expressive language of the Pernambuco people, even though literature has ignored this Amerindian cultural vector as a marker of the people's identity and local culture. The music, dance, and expressive language of the caboclinhos' singing express a common identity in the perré rhythm that can be observed as present in other local expressive forms of urban music, such as forró, baião, xote, coco, maracatu, embolada, ciranda, and other forms expressive of local identity. In this approach, perré emerges as an element that verifies the presence and importance of an indigenous language first identified around 1535 by Father Fernão Cardim. This expressive form, currently shared in the everyday lives of popular culture, both oral and media-based, represents markers that reveal vectors of nuances in popular culture that may have originated with the local Indigenous people. This paper focuses on a dialogical ethnomusicology that seeks to understand the intersections between media music and a possible Indigenous origin of common patterns in Pernambuco culture. This approach emerged inductively from the analytical intersection of testimonies and testimonies gathered in ethnographic fields since 2003, as well as from the examination of forms of representation as a musician, teacher, and researcher.

Keywords: Dialogical Ethnomusicology. Perré. Musical Language. Indigenous Standard.

RESUMO

No cotidiano do panorama sonoro pernambucano percebe-se vínculos entre a linguagem musical de povos originários locais representados nos grupos carnavalescos de caboclinhos. Esses vínculos apontam para presença de um padrão expressivo local que influenciou na edificação da linguagem musical e expressiva do povo pernambucano, ainda que a literatura tenha ignorado esse vetor cultural ameríndio como marcador de heranças identitárias do povo e cultura local. A música, a dança e a linguagem expressiva da cantoria dos caboclinhos exprimem uma identidade comum no toque do perré que pode ser observado como presente em outros modos expressivos locais da música urbana, como no forró, no baião, no xote, no coco, no maracatu, na embolada, na ciranda e outras formas expressivas da identidade local. Nesta abordagem, o perré emerge como elemento de verificação da presença e importância

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de uma linguagem indígena primeiramente identificada por volta de 1535 pelo padre Fernão Cardim. Essa forma expressiva, atualmente compartilhada nos cotidianos da cultura popular de tradição oral e midiaticizada, representa marcadores que revelam vetores de matizes da cultura popular que podem ter origem no índio local. Esta comunicação centra-se numa etnomusicologia dialógica que busca entender as interseções entre a música midiática e uma possível origem indígena de padrões comuns da cultura pernambucana. Essa abordagem emergiu indutivamente do cruzamento analítico de depoimentos e testemunhos adquiridos em terreno etnográfico desde 2003, como também da verificação de formas de representação como músico, professor e pesquisador.

Palavras-chave: Etnomusicologia Dialógica. Perré. Linguagem Musical. Padrão Indígena.

RESUMEN

En la cotidianidad del panorama sonoro pernambucano se perciben vínculos entre el lenguaje musical de los pueblos originarios locales, representados en las agrupaciones carnavalescas de *caboclinhos*. Estos vínculos apuntan a la presencia de un patrón expresivo local que influyó en la construcción del lenguaje musical y expresivo del pueblo pernambucano, aunque la literatura haya ignorado este vector cultural amerindio como marcador de herencias identitarias del pueblo y la cultura locales. La música, la danza y el lenguaje expresivo del canto (*cantoria*) de los *caboclinhos* expresan una identidad común en el toque del *perré*, que puede observarse como presente en otros modos expresivos locales de la música urbana, como en el *forró*, el *baião*, el *xote*, el *coco*, el *maracatu*, la *embolada*, la *ciranda* y otras formas expresivas de la identidad local. En este abordaje, el *perré* emerge como elemento de verificación de la presencia e importancia de un lenguaje indígena identificado por primera vez hacia 1535 por el padre Fernão Cardim [[nota: en este resumen se indica "hacia 1535", mientras que en otro texto del mismo autor el registro de Fernão Cardim se data en 1584; se recomienda verificar y uniformizar la fecha]]. Esta forma expresiva, actualmente compartida en las cotidianidades de la cultura popular de tradición oral y mediaticizada, representa marcadores que revelan vectores de matices de la cultura popular que pueden tener origen en el indígena local. Esta comunicación se centra en una etnomusicología dialógica que busca comprender las intersecciones entre la música mediática y un posible origen indígena de patrones comunes de la cultura pernambucana. Este abordaje emergió inductivamente del cruce analítico de relatos y testimonios obtenidos en terreno etnográfico desde 2003, así como de la verificación de formas de representación como músico, profesor e investigador.

Palabras clave: Etnomusicología Dialógica. Perré. Lenguaje Musical. Patrón Indígena.

1 INTRODUCTION

This communication was born from the identification of the occurrence of markers of local Indigenous identity in the expressive music of Pernambucan popular base. The importance of this verification emerged from the concrete identification of an order of sociopolitical-cultural values (and their unfoldings) determinant of a sonic panorama of urban and mediatic everyday life that proved associable with the expressive habits and practices of Indigenous matrix. Such a category of data brings to the worldviews of present times a new line of comprehension and valorization of the Amerindian element in everyday life, opening upon this element of local identity more inclusive and multifaceted forms for what is heard and how it is heard on global planes.

The problematic of this verification lies in the fact that such sociopolitical-cultural values linked to an Indigenous matrix manifest themselves in the intuitive and colloquial thought of musicians and popular *brincantes* without these subjects having clear awareness of their existence, even though it is there in their particular ways of thinking such musicked practices. Moreover, this line of intuitive and colloquial thought of Indigenous matrix verified here, present in local popular music (mediatic and of oral tradition), revealed itself in the quality of active vectors present in the culture and musical language of the Pernambucan people, even though politically these vectors are socially disregarded and, for this reason, invisible or barely perceptible.

However, even if socially and politically concealed and appropriated under the decolonial veil of shame and forgetting, the lack of knowledge of these links (in the discourses, testimonies, and arguments that I was able to ethnograph in the terrain of roots and mediatic music) does not represent the nullity of their existence in the cognitive complex of musical behaviors in the *xotes*, *baiões*, *cocos*, *cavalo-marinheiros*, *reisados*, *marujadas*, *cirandas*, and other expressive practices that nourish the peculiarity of a supposed musical accent of the Pernambucan people. Would elements of Indigenous matrix be contained there? Or is everything that is heard or musically thought in Brazil, in the Northeast, and in Pernambuco of a solely European and African base? How do the various cultural vectors and matrices of a hybrid culture such as the Brazilian one in fact manifest and occur in everyday life? And could it be that the musical expressive heritages of the various cultures of local original peoples were totally eradicated, or never existed? And if they existed, or still persist in a veiled manner, how do they manifest themselves in local thought?

This line of concerns and interests came to guide the present approach, considering that its unfoldings may come to open new lines of contribution for future indigenist studies regarding elements or vectors determinant of the proper and particular ways of Indigenous

cultures in each geopolitical space of occurrence (community, neighborhood, city, or region) and of the ways in which people think their practices. A dialogical proposal that favors giving equal value both to the voice of the makers of their own identity and to the voice of the discourses of the specific literature.

The problematic perceived regarding barriers and impediments to listening to the voices of the holders of knowledge emerging from local orality directly impacts the very practice of the oralized tradition in present times, for it causes a potential effect of misinformation. After all, what is "Indian music" (*música de índio*)? How does one distinguish it? What is its occurrence and impact in the globalized world?

And from this viewpoint, science, in its eagerness to systematize and categorize diverse intangible forms of knowledge on structuralist bases, errs by not considering the main variant and edifying element of the ethnographic approach: the original holder of the knowledge. And as a consequence of this action, groups of eminently distinct cultural bases come to be framed within a single profile arbitrated by the systematizer, like pieces of the same category, similarity, or functional equality on a game board. From which there historically resulted conflicts between distinct groups placed in the same arena of values and relations by folklorist approaches, inducing them to dispute for recognition and social respect. As when expressive groups of a locality compete among themselves for possession of the legitimacy and authenticity of their practice. Or when the very actions of cultural policies reinforce a hierarchy of competencies and the competition between expressive groups for the authenticity and peculiarity of their practices.

As I inductively verified in recent studies of local music and tradition (Souza 2006; ...), these Indigenous-based vectors manifest themselves in a veiled manner through a complexity of historical factors, in turn, as already mentioned, aggregated to a decolonial order of conceptions. And as pointed out, in the arenas of my investigative terrain their manifestation emerged inductively from the ethnographed voices and ordinary ways of doing, leaping to my eyes as signs that progressively alerted my sensibility to the existence of certain marker vectors not previously perceived. For this reason, the present communication projects my interest toward the comprehension and understanding (induced and systematized) of human musical thought from a dialogical approach that considers the voices "of what is said," "about which it is said," and "of what is done." In this sense, the data contained here sought to make evident musical and extramusical values through a qualitative, exploratory, and investigative methodology of "ways of doing" that are not controlled by the dominant musical grammar and by the formal pedagogical praxis of Eurocentric base, which predominantly governs, regulates, and controls musical thought in contemporary society.

O dom, o talento e o marcador de base indígena na música local

In the colloquial musical practice within popular expressions that I verified together with subjects who are holders of a popular language intimately linked to matrices and nuances stemming from oral tradition, I perceived the recurrence of intuitive and spontaneous abilities and competencies that, when successful, emerged from a familial, communal, and emotive experience acquired by direct contact with orality. The terrain of observation encompassed twelve municipalities of the Pernambucan coast (Goiana, Itapissuma, Itamaracá, Igarassu, Paulista, Olinda, Recife, Cabo de Santo Agostinho, Pontezinha, Ipojuca, Nossa Senhora do Ó [[nota: o original traz "Nossa Senhora do Ò"; provável erro de acentuação por "Nossa Senhora do Ó"]], and Tamandaré) and four municipalities of the *agreste* (Caruaru, Camocim de São Félix, Sairé, and Agrestina) [[nota: o original anuncia "doze municípios" do litoral, mas lista onze nomes; recomenda-se verificar]], observing musicked practices and their expressive ways of music-making, resorting to semi-structured and open testimonies in a context of participant observation as an instrumentalist and apprentice of the local ways of performing.

The ethnographic process was developed from 2003 to 2018. Sixty practitioners of various popular manifestations were interviewed. From the total number of interviewees, on the basis of the attribute of the level of collaborativeness, I selected voices with which I developed an ethnographic study that resulted in a doctoral dissertation and the respective book on the *coco de roda*. And from this investigative terrain I cite, as an example, some of the ethnographed voices:

Figure 1

SOME ETHNOGRAPHED VOICES



From this contact in diverse arenas of local expressive production, I identified the validity of fragments of testimonies from which an Indigenous vein was pointed to in practices predominantly identified as of African base in Brazil. From which I considered seeking to understand "what it is like to make music and to musicalize social contexts outside formal thought," since the spontaneous thought of a colloquial language, in its practicality, tends to be little considered by common sense for not being strictly linked to the dominant method, proper to official knowledge, oriented by an objectivity and systematization grounded in theoretically reliable, sovereign, neutral, precise, and verifiable procedures. Knowledge that in practice does not legitimize the emotive and intuitive practice of non-literate practices, such as those of oral tradition, by considering them a source of acritical knowledge on the part of those supposedly incapable of exercising or demonstrating abilities to evaluate or cognitively question their own propositions in a well-founded manner. Framed within this illiterate category are the expressive practices of original peoples, Roma people (*ciganos*) [[nota: "ciganos" traduzido como "Roma people"; termo preferencial em inglês — recomenda-se confirmar se o autor se refere especificamente ao povo Roma/Romani]], subaltern cultures, and suburban minorities, as tensional arenas between center and periphery perspectives. A datum that, reflexively applied to the present time of intercultural and interclass relations, demonstrates the existence of bordering barriers as to what may be legitimized and recognized without reductionist stereotypes. Barriers that inflict shame or a feeling of inferiority upon those holders of unwritten (*ágrafa*) ways of doing not celebrated by erudition—such as the colloquial category of those popularly called: self-taught (*autodidatas*), "ear musicians" (*músicos de ouvido*), "intuitive musicians," "musicians by hearsay" (*músicos de orelhada*), "fixers" (*quebra-galhos*), "jacks-of-all-trades" (*pau-prá-toda-obra*), "blind knots" (*nó-cego*), "do-it-alls" (*faz-tudo*).

Moreover, the complexity of this problematic, of decolonial base, reaches the ways in which even ethnographic approaches may come to dwell on expressive practices as describable phenomena of the exotic, the mystical, the magical; formulating essentialist readings and the reification of identities, worldviews, or cultures. A problem that demands a serious revision, considering the terrains of investigative ethics, since it involves processes of transforming identity values—intimate and private—into a spectacle of others' lives through a theatricalization of their everyday lives, in which individuals become actors, characters, spectators, or extras in their own lives. This essentialization runs the risk of transforming the creative power of popular expressions into something mystical, exotic, and spectacular, in addition to disseminating it as something articulated in a little-reflected manner, captured out of thin air in an unforeseen, random, and involuntary way—as if each creation were unique

in itself due to pure limitations of conscious reproducibility on the part of its maker. A datum that fosters judgments that this colloquial practice manifests itself through a vague mode of creation, without critical depth. And against the grain of this line of judgments, my approach sought to identify what is exact, reflexive, rational, and coordinated in the ways of thinking of the practitioners of expressions linked to orality, considering their projections in popular and plural practices already mediatized, such as the *forrós* and the *bregas*, for example. After all, would we be able to recover the real value of Indigenous contributions in what we do and hear in everyday life?

This theme further points to the fact that the musical thought of Indigenous peoples needs to be better considered for its real and possible contribution to the understanding and comprehension of significant markers of the musical thought in activity on the expressive scene of Pernambucan culture. Beyond which, this awareness may favor the legitimation of the voice of local original peoples in the eyes and discourses of public policies, the entertainment industry, and mediatized terrains regarding the role of Indigenous culture in the edification of the identity of the Pernambucan people. It is hoped that from this recognition a new reading of characteristics of popular expressive production will emerge, through possible links with Indigenous traditions, which at present remain restricted to the field of contemplation without much contributive visibility.

The very idea of improvisation in performative phenomena that are open and free of a regular prediction of their results—such as the *embolada* and the *repente* in popular *cantoria*—came to be framed as acritical music, for being possibly produced without concrete reflexive questioning in light of erudite formalism, or for emerging from beliefs that are imprecise or unfounded by tradition, or even as the attribute of a gift. So that, for the common sense of society, the practice of Indigenous peoples and other minorities could not be produced by a system of its own outside the parameters and criteria of scientific knowledge, leaving actions of valorization of and interest in this ancestral knowledge only in the spheres of scholars of Indigenous culture and knowledge.

In a conventional manner for common sense, improvisation implies being a spontaneous competence to create music whether through vocal or instrumental interpretation, and in these terms, in contemporary music, musical improvisation requires technical ability, theoretical knowledge, sensibility, and musical baggage, even though it represents a practice that seeks expressive freedom, conceiving that musicians create and interpret melodies, rhythms, and vocalizations in a spontaneous manner. And as a technical attribute of the performer, eruditized improvisation demands formal processes of learning and production, even while being articulated through the exercise of new experiences and

adaptations of an already established musical proposition. In its difference from the intuitive practice of the popular and oral-tradition musician, this improvisation is predictable and often formally prescribed. Thus, musicians of mediatized spaces use specific and peculiar techniques previously developed for improvisation, whereas a singer (*cantador*) of oral expressive practice appears, to common sense, not to have a technical and conscious resource for the articulation of his sonic propositions. And in these terms, I observe that my effort has as its object the promotion of an avenue of access to the comprehension of the intuitive and spontaneous knowledge of colloquial languages present and influential on the popular music scene of Pernambuco, based on the testimonies and accounts collected and on participant observation in the investigative terrain. And that the reflexive character of my approach, in the use of systematizing procedures resulting from dialogical ethnographies within the domains of ethnomusicology, seeks solely to make viable an interface space which, mediating between oralized and eruditized thought, favors a mutual and favorable approximation between the observer (society) and the observed (the practitioner who holds the knowledge). I further observe that the focus on Pernambucan culture is due to my extensive experience with local expressive practices of Pernambuco and their forms of representation, a datum that enables a closer view of the symbolic discourse and of the imaginary inserted in and circumscribed to these practices.

Indeed, beyond my parental link with the local Indigenous culture through *caboclo* ancestry with deterritorialized Indigenous people, I point out that a significant part of my systematic view of an Indigenous vector that is disseminated and influential in the everyday thought of the Pernambucan music scene emerged directly and indirectly from collaborative accounts and testimonies that pointed to the existence of an original pattern of an essentially Indigenous base, which, in contact with other non-local matrices (of external origins that arrived here in contexts of mobility and migratory processes), shaped expressive forms determinant of what is currently understood as Pernambucan music. A pattern identified here through the contrametricity (Kolinski 1960, 1973; Arom 1985, 1988; Jones 1959; N'Ketia 1975; Sandroni 1997, 2000, 2001, 2002) of its articulation in the thought of the musician, *brincante*, and *aficionado* who resorts to it whenever stimulated by diverse contexts in which one can or is allowed to react musically. This articulation being symbolically associated with forms of metric accentuation of speech, of steps, of gestures, and of rhythmic subdivisions in each expressive practice observed by me. Whether this practice was of a profane or religious character, of the ritual of work songs or of cults to spirits and *encantados*, of the mediatic scene or of oral tradition.

The reflection on migratory and mobility processes must certainly be considered in this tensional field and interface of verification of the construction of traditions and identities, from which hybrid behavioral and expressive forms emerged on Brazilian soil. And in these terms, the reflexive category of the present approach favors and seeks ethical planes of clarification and comprehension of things that the official literature and the cultural policies have often not answered, owing to having predominant attention on the descriptive method of direct and concrete data of phenomena isolated in themselves—as if there were no possible crossings and interconnections between ritual and mediatic music, or between the expressive vocabulary of a *maracatu* drummer (*batuqueiro*) and percussion arrangements of the *mangue beat* style, or even between an official performance formula of the *forrós* and the inherited motivations that manifest themselves in the expressive/interpretive performance of a *forró*, for example.

However, even though the bases and patterns of cognitive thought are little revealed during the musical practice in the everyday of the oral-tradition and mediatized music scene, it is notable that there exist certain correlations between the concrete performance and a common pattern intuitively activated by the memory of oral/popular base. But would the metacognitive resource of resorting to a common pattern in memory be intuitive or reflexively thought from some reference already considered? Moreover, one cannot forget that the awareness of these correlations is vulgarly conceived by the common sense of society as gift, talent, racial competence, and popular creativity, mainly when the actor of the action is considered an amateur, self-taught, or an ear musician.

To consider a reflection on symbolic terms such as gift and talent is of great importance for us to perceive that culturally inherited knowledge, whether in an oralized form or formally prescribed, activates the articulation of metaphors and allegories of the quality of the acquired knowledge and of the respective forms of acquisition. When the concept of gift is thought of, the idea of a gift or present is activated—that is, something received without apparent prior request, implying the representation of an innate capacity to perform a given action with dexterity in various contexts, even the most complex for most people. So that to think of a gift for playing an instrument or creating apt phrases in a *coco de roda*, for example, would imply our considering that the individual was born with a natural ability/aptitude, and that it is their nature to give successful performances even without physical effort or reflexive effort. And under this conception, only someone holding a divine and non-transferable gift would be able to play a *coco de roda*, and any individual without this gift would never be able to create or musicalize a *coco de roda*.

In its rigidity and incompatibility, this line of conception denies the possibility of the acquisition of certain forms of knowledge, competencies, and abilities by those who do not possess an innate gift or talent to perform on the local language of oral base, thereby making the present approach a challenge to be trodden in future studies.

Even so, the sonic universe to which I had access was fluent and rich in expressive resources, and the ways of making and thinking this production pointed to a regular pattern present in various local manifestations, as if all converged from one and the same source. And the accounts of personal processes of interpretive creation of these practicing subjects pointed to the rhythmic pattern of the *perré*, a constituent touch of the local *caboclinhos*. This datum induced my view toward the possibility that the recurrence of the *perré* pattern revealed that the local culture drank from this same heritage, and that its presence in Indigenous ways of performing their rituals, associated with the datum that the *cocos* of the *agreste* of Pernambuco have a clear relation with the *perré*, made possible my proposition that the marker of this rhythmic recurrence could be named locally as *perré*.

On the basis of this hypothesis, I came to analytically cross-reference the structures of popular oral-tradition rhythms occurring in the state of Pernambuco, considering that these rhythms originating from oralized processes are applied to the current language of the Pernambuco music scene, which permeates *cocos*, *cirandas*, *cavalo-marinhos*, *caboclinhos* (*perré* touches, *baião* touches, *guerra* touches, and *macumba* touches), *xotes*, *baiões*, *galopes*, *marcha-juninas* (*quadrinha* touches, also called *rastapés*), *bumba-meu-bois*, *pastoris*, *mazucas*, *forró de pé-de-parede*, *capoeira*, *ijexás* (*afoxés*), *pontos de esquerda* of the *jurema sagrada* and *umbanda*, *maracatus de baque solto*. All could be articulated from the awareness of the *perré* pattern as a marker of the expressive identity of local musical thought.

Considering the importance of an awareness of patterns and interpretive lines of each cultural matrix that builds the hybrid character of the expressive identity of Pernambucan music, this article seeks to highlight the cultural contribution and a consequent recovery of the social value of minorities still little considered in Brazilian society, as in the case of the original peoples. And in this conflictive process of building the complexity of a local expressive culture, there is no way to disregard processes of exodus, migration, or diaspora, and their unfoldings in life histories and in the construction of collective identities.

Paraphrasing Dan Lundberg (2010), I consider that the categories defining the identity markers of the music of a culture require the notion of ownership in their sharing for the definition of the respective identity marker—as in the case of the sharing of songs on the part of distinct groups [Kurds and Turks] studied by Lundberg (2010, pp. 28-29). However, as a

significant point of such a category of approach, efforts at the identification of the respective marker become important. And consequently, in order to think Pernambucan music in its bases, it becomes relevant to identify the respective identity marker of current languages, since the conception of a specific place of manifestation demands a local practical awareness of its use.

O perré como marcador partilhado

In the field of my observations of the musical practices that I verified in Pernambuco since 2003, I observed the recurrence of a pattern of a rhythmic cell shared by popular singers (*cantadores*) of local oral tradition and its use in the performances of the other artificers of practices such as those of the *maracatus*, *baião*, *xote*, *cavalo-marinho*, *coco de roda*, *mazuca*, *ciranda*, *pastoril*, and other local manifestations, constituting itself an element proper to the singular performative and expressive language of the culture of the people.

The ethnographic terrain reinforced that there are important connections of markers of local Indigenous matrix with the creative and interpretive thought of folklorized practices of oral tradition, and the unfoldings of these practices in particular processes of reappropriation, readaptation, and application of these markers in urbanized music. And the most curious thing is that the historiography of the practice appropriated through the exercise of orality was, and still continues to be, supplanted by an external, politically organized paradigm that silences voices of collective memory—even though this memory, without even perceiving it, unconsciously makes use of its distant heritages of making *forrós*, *cocos*, and *maracatus* in the metropolitan region of Recife, precisely where the impact of the erasure of memory occurs with greater force and intensity.

In these spaces, the accounts and testimonies, collaboratively collected in participant observation, made it possible for me to hear spontaneous attempts at descriptions and clarifications—sometimes detailed—of the particular ways of each singer and performer to make his music, when they resorted to what they learned by imitation, immersive induction, or deduction of what intuitively reached their ears through the maternal, parental voice, religiosity, or community. The memories were referred to as heritages that they should perpetuate as an identity commitment assumed with their musical roots, which, even though symbolic or socially masked, could, through them, become visible and concrete. As if it were something intangible in the eyes of the world, even though it was there materialized through their actions.

In a testimony given on the radio broadcast of the Festival de Inverno de Garanhuns in 2001, Zé Neguinho referred to his practice as a moment full of relation with life:

É um prazer que eu sinto. Ali (no coco) eu não choro, ali eu não me embriago, ali eu não censuro ninguém e ninguém me censura. Eu mato as minhas vontades, as minhas paixões. É mostrar música, trabalhar com música (Zé Neguinho 2001, programa de rádio do Festival de Inverno de Garanhuns).

Zé Neguinho referred little in public regarding the facts of his intimacy and his initiating links in musical practice, preferring to remain silent. In part, the silence was employed by him to safeguard a respectable reputation for his practice before common sense. However, the media, through some *brincantes* and *aficionados*, considered him religiously linked to Afro-Indigenous cults (*jurema sagrada*) or Black-African ones (*xangô* or *umbanda*). And in this respect, the presenter Roger de Renor of the local program "Som na Rural," which was broadcast on TV Brasil in 2011, identifying the creative and interpretive peculiarity of Zé Neguinho through a supposed link with *terreiro* religiosity, pointed out:

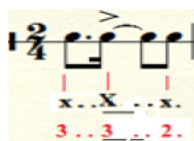
O compositor e cantor Zé Neguinho do Coco é dono de uma voz aveludada e de uma performance extremamente delicada e elegante. Seu coco tem vínculos mais estreitos com o candomblé e isso faz com que sua música se diferencie da obra de coquistas tradicionais. Espécie de seresteiro do coco moderno, Zé Neguinho do Coco, ao compor a música Pau de Quiri, ainda criou algo novo: o coco-canção. A composição, gravada nos anos 1990 pela banda Cascabulho em seu álbum de estreia, divulgou a obra de Zé Neguinho, que passou a ser requisitado com frequência para shows e festivais e se tornou referência para jovens músicos da cena recifense (Roger de Renor, Som na Rural, TV Brasil, 2/5/2011).

However, when in face-to-face dialogue with Zé Neguinho, I identified in his words the existence of concrete vectors with the liturgical ritual as a modeler of his *cantoria* and of his creative inspiration and improvisations. Zé Neguinho did not react negatively to my proposition of the existence of a marker that regulated his musical propositions. He made clear that there was some cultural element that gave him security in his musical practice, as if it structured his reasoning in the act of performance, and that through this marker he built his reflexive criteria. Moreover, from the contact I had with Zé Neguinho, it seemed to me that his repertoire and expressive lines of creativity represented greater connections with the musical practices associated with the *jurema sagrada*—a religious cult of Indigenous ancestry, very influential in what is currently known as *umbanda*, and which in the first half of the 20th century was affiliated with cults locally called *catimbó* (a shamanic cult) and *macumba*. However, regarding the modes of use and non-religious relations in musical practice, Zé Neguinho took care to assure of the necessity of personal responsibility to know how to separate the ritual from the merrymaking (*brincadeira*), distinguishing spaces of professional commitment and devotional commitment, even though these spaces frequently intercrossed. This frank, trustworthy reflection had pointed out that the symbolic values that

he considered were underpinned by a pattern of reasoning that allowed him to dialogue between realities. And because I consider the rhythmic element of the music of the oral traditions as one of the constituent foundations, I came to center my efforts of observation and decoding on the rhythm of speaking, of musicked walking, of singing, of the accentuation of syllables, of the pulse of the dance, of the beating and dragging of the feet, of the responsorial claps, of the playing of the *ganzá*, of the jingles of the *pandeiros*, of the pulse of the drums.

In focusing on the rhythm in the *cocos*, *maracatus de baque solto*, *cirandas*, *capoeiras*, *xotes*, and other local expressions, I came upon the recurrence of the contrametric pattern 3 + 3 + 2 (Kolinski 1960, 1973; Arom 1985, 1988; Jones 1959; N'Ketia 1975; Sandroni 1997, 2000, 2001, 2002), which produces a sonic effect similar to what in past times was named *tresillo* (Fernandez, 1965; Sandroni 2002), and which is observed evidently in the practice of the *perré* touch of the *caboclinhos* of Recife. And from this contrametric recurrence in different musical styles and forms, I perceived that there was, in the *perré* touch of the *caboclinhos*, a strong candidate for the understanding of processes in which a symbolic cognitive thought is manifested that is determinant of local abstract languages such as those of musical practice—which promotes, as an unfolding, pedagogical and systematized processes for learning the Pernambucan musical language. Mainly because the term *perré* is local, musical, and directly associated with markers of Indigenous base, this article proposes the "*Perré*" as a marker of Indigenous identity in Pernambucan culture.

The notion of a rhythmic cell that is influential in oral-based traditional practices refers, in this case, to the erudite concept of *tresillo*, used by Fernando Ortiz Fernandez (1965) for Cuban music. This cell presents itself in the rhythmic formulas present on the music scene of the Brazilian Northeast with accentuation on the irregular syncope at the end of the first beat, as I graphically represent below:



Its occurrence was recorded in Latin American rhythms such as the Cuban *habanera*, the Argentine tango, the Dominican *merengue*, and several calypsos of Trinidad (Storm Roberts 1972, p. 52 apud Sandroni 2002, p. 103), as well as in South American rhythms such as the American tango, the *tango gitano*, the Brazilian tango (*maxixe*), *samba*, the Argentine tango, and other species of the same "family," whose "primitive classical" formula would be the "*habanera* rhythm," and the "characteristic syncope" one of its variants (Vega 1967, pp. 49, 64).

Sandroni (2002) proposed seeing in the *tresillo* the most simplified version of the symbolic thought of the performer, considering the validity of adopting this rhythmic formula as a strategy of systematic argumentation for various expressive forms in Latin America, in Brazil, and in Africa. Indeed, as this author points out, the theme involving this rhythmic articulation has a vast terrain of assertions, which in part converge in their importance, and in part diverge owing to controversies regarding form, notation, representations, and nomenclature—for which Sandroni proposes, as a resolution, that we consider the *tresillo* form as the minimum common denominator of the set of variants that can be articulated from the conception of the contrametric pulse $3 + 3 + 2$. This author warns and reiterates the existence of an equivalence among certain rhythmic formulas activated to characterize peculiar properties of given musical genres, pointing out that this typology of rhythmic formula perceptible in various expressive practices should not be centered on conceptualizing solely a single genre, but rather as an open formula capable of affording equal fluency of one and the same symbolic thought that is effective in a multiple set of genres. Corroborating this perspective, the present article seeks to consider the applicability of this multifaceted knowledge as a universal tool for the symbolic thought of musicians, dancers, and other categories of relation with expressive identity forms, of Pernambuco, of the Northeast, and of Brazil.

Regarding the complexity of the structuralist idea that an emic term should give way to a single universal term forged outside the local perspectival reality, this emerges in the human sciences as a complicating and inhibiting element of local identification, promoting a disinterest on the part of local subjects in assimilating the dominant perspective, since it seems arrogant and inappropriate to them. In these cases, in my opinion, a certain academic sensibility is lacking in dealing with the truths of the other. Thus, my proposal seeks to give an empathetic voice to the terms used locally, so as to promote not only adherence to the central theoretical proposition of an official terminology, but to promote a friendly appropriation that stimulates states of local self-identification. And in this perception, this article makes use of the emic term *perré* for what Sandroni (2002) considered appropriate to be *tresillo*, considering it pertinent for us to reflect when the main object of self-identification (the emic term) is an extramusical vector for the determination of the awareness of oneself.

In this segment of propositions, Sandroni proposes considering that the recognition of this rhythm, as a marker of identity discourses, may correspond to extramusical ideas that afford the difference between distinct cultural values, even if common in the rhythmic pattern. The rhythmic element thus perceived would answer to peculiarities necessary for the understanding and modes of use of a common pattern for it to be recognized emically

according to the parameters of each culture. And thus, the criteria that delineate differences and identities would correspond to the extramusical elements proper to each culture, which would make acceptable distinct names for the same foundation (*Tresillo* in Cuba, *Perré* in Pernambuco), without each identity terrain suffering from the imposition of the center of power upon the periphery. Thus, Sandroni allows one to perceive that many of the definitions of an expressive practice lie in the gaze of alterity that common sense gives to the practice, such as "mestizo," "Afro-American," "popular." And in these terms, the perspectival bias of what is designated Black music, Northeastern music, or "Indian music" aggregates extramusical criteria of the observer (outsider)—which, even though they are criteria of external cultural origin, in arenas of decoloniality have legitimacy and political autonomy to define.

Emically, this rhythmic structure is expressed by the contrametric pattern 3+3+2 in the interpretive forms of *cantoria*, foot-tapping, and the articulation of the instruments, or even in the manner of being of the pattern that I perceived as most effective for the representation and learning of rhythms of local expressive practices. The variety of application of this pattern revealed itself projected onto other musical forms such as local *samba* itself, *piseiro*, *sertanejo*, *swingueira*, the *manguebeat* movement, and national *funk*, from the *terreiro* touches, as Ulloa Sanmiguel (1998) observed in the study of *samba*.

Pensando a sonoridade popular de Pernambuco a partir do perré

In the case observed in expressive arenas of Pernambuco, I observed the predominant use of the contrametric form 3+3+2, there being significant contexts of performative and compositional interpretation that made evident two variants of the 3+3+2 form, for which reason I identified the forms 2+3+3 or 3+2+3 as a common expressive resource present in the local sonic practice. These possibilities of variations of the *tresillo* pattern (3+3+2) open the spectrum of possible forms of relation between local personal and collective motivations and varied modes of interpretation and performative representation of musical thought. This datum in itself potentially shakes a fixed idea of the *tresillo* structure as 3+3+2, conceiving for the performer a broader range of combinations, even though the pattern is there under a treatment dislodged in the time-space of perception and functional thought of the expressive proposition. Thus, a singer may make use of a variant whenever he particularly feels it has more applicability to what he hears, while another performer might follow another variant. And the use of these models of variation may give a different shine or coloring to the final sonic ensemble. As well, the use of a given variant may be more applicable in specific contexts of creation or even interpretation.

In the ways I observed in the terrain, their uses were sometimes strictly linked to the metric structure of the rhymes, sometimes linked to the metric-interpretive style of the *cantoria* activated, sometimes strictly linked to the local tendency of creation or interpretation of the respective rhythm.

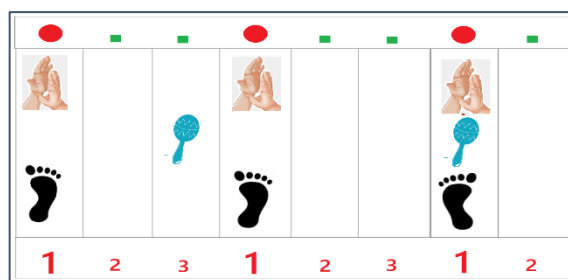
The rhythmic pulsation determined by these types of linkage cited above may activate the way in which the practitioners begin the articulation of the 3+3+2 pattern (or its variants 2+3+3, 3+2+3) and give it continuation. A datum that mirrors the experience and mastery of each performer with such possibilities of a thought matrix of the *perré* patterns, as well as the competence and ability to flow articulations in a crossed or hybrid manner according to his free will, bringing to the performance an interpretive richness of personalized languages, in which the personhood of the thought and voice of the performer sets the tone of his expressive identity. Thus, the open and generative thought in the expressive lines of popular language makes it unique by projecting the self of the performer.

Below, as an example, I present a relational representation between claps, foot-tapping, and the regular marking of the rattle (*chocalho*) (in the local Indigenous interpretive style) in expressive practices of the *coco* and of the movement of the *passeio* of the *mazuca* of Agrestina:

In this reflexive procedure in the *coco* and in the *passeio* of the *mazuca*, the initial intention activates the claps with the right foot going simultaneously to the front of the body; next, a solo marking of the rattle (*chocalho*) is made, which is immediately followed by new claps and the right foot beating simultaneously next to the body; this movement is resolved with the marking of the rattle, now simultaneously with the claps and the beating of the left foot.

Figure 2

Relational representation between metric thought, claps, foot-tapping, and the rattle in the 3+3+2 pattern of the perré.



Under this guide induced by the sonic or extramusical context, the participants aurally identify the *perré* pattern and interact successfully, without the musician or singer indicating

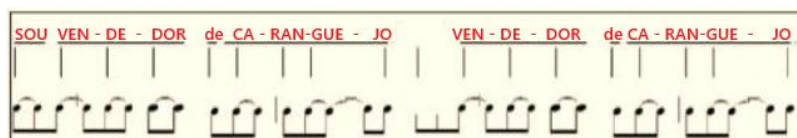
it explicitly. That is, this prompt competence of identification reveals that there is a common and shared tacit knowledge, as of a rule already culturally established. And in its recurrence, the contrametric thought allows some possible articulations applicable to interpretive lines on the planes of performance, creation/composition, or improvisations, of which I present below:

Figure 3

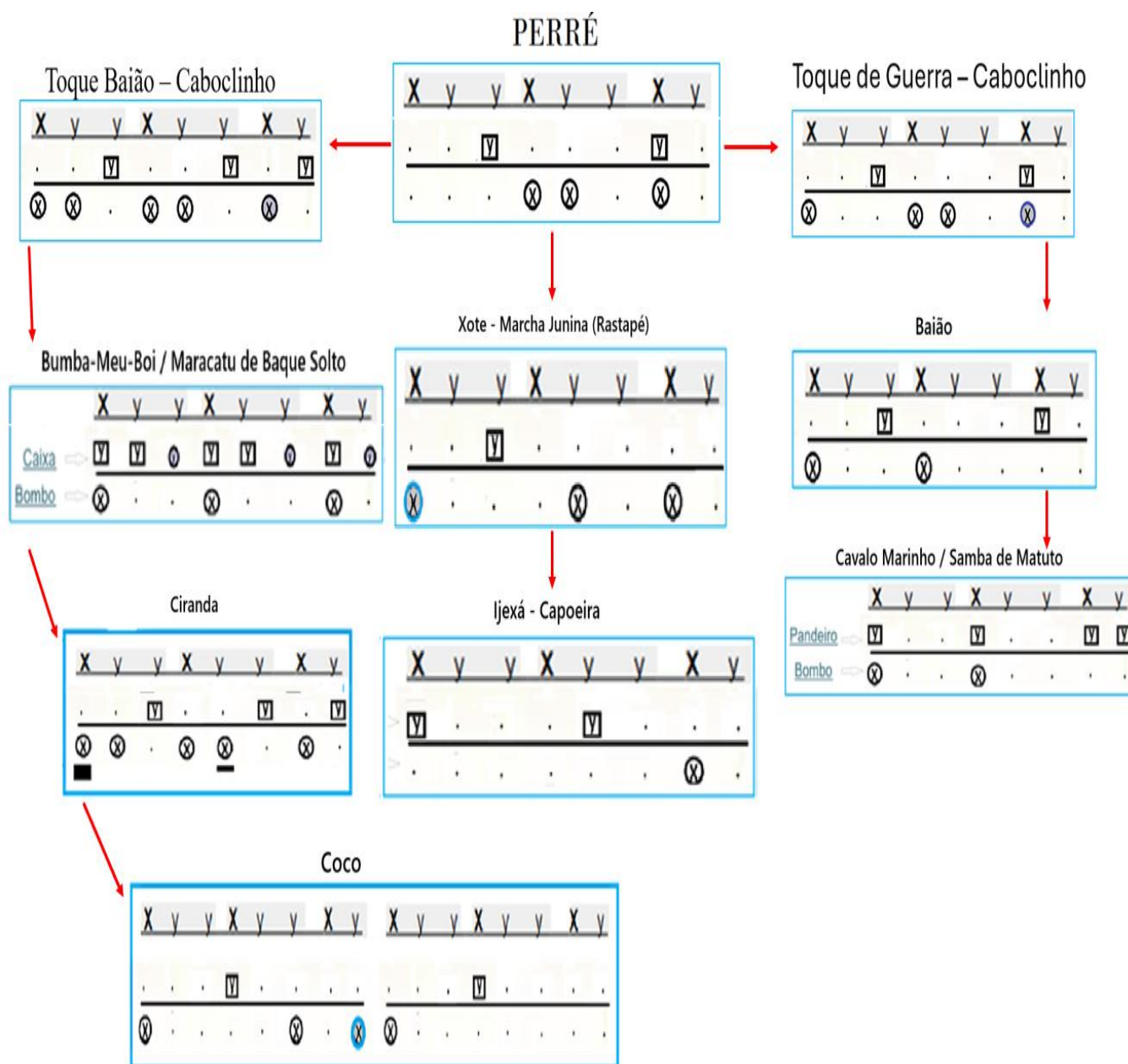
Variants of the *perré* pattern

Padrão Perré de 3 batidas = 3+2+3	X	.	.	X	.	X	.	.
Padrão Perré de 3 batidas = 3+3+2	X	.	.	X	.	.	X	.
Padrão Perré de 4 batidas = 3+2+3	X	.	.	X	.	X	.	X
Padrão Perré de 4 batidas = 3+3+2	X	.	.	X	.	.	X	X
Padrão Perré de 5 batidas = 2+3+3 (a)	X	.	X	X	.	X	X	.
Padrão Perré de 5 batidas = 2+3+3 (b)	X	.	X	X	.	.	X	X

The *cantoria* emerges as the main element that activates expressive behavior, and in these cultural practices the proposition of the rhythm is inductively established by the sung melody or the syllabation of the sung theme. As in the example of a work song referred to by Pombo Roxo in 2006, when the contrametric pattern 3+3+2 is perceived in the structuring of the syllabic thought of the *cantoria*:



This characteristic of articulation is disseminated in the customs of the rituals of popular Catholicism, of *brega*, of the work song, of various celebrations of the local June (*junino*) and Christmas periods. From this perspective, the *perré*, here considered an interface element in arenas of interculturality, emerged as a dialogical and shared marker of the local expressive language. In these terms, the *perré* emerged inductively through the voices of the terrain as a marker of an Indigenous expressive language in the interpretation of the rhythm of traditional rhythms such as *caboclinhos*, *bumba-meu-boi*, *maracatu de baque solto*, *xote*, *marcha junina (rastapé)*, *baião*, *ciranda*, *ijexá*, *capoeira*, *cavalo-marinho*, *samba de matuto*, *coco*, in addition to the unfoldings of these rhythms in the mediatic music of the *forrós*, of *piseiro*, *rock mangue beat*, and other styles of the local globalized scene. As per the graphic below and the respective sound examples at the link <https://on.soundcloud.com/pbmKT2GM7nFrsCrc8>.



2 FINAL CONSIDERATIONS

The expressive practices of the Brazilian Northeast suggest identity ties that allow their actors to dialogue fluidly among themselves through the use of common elements of language that, subliminally and metacognitively, mark the practices in the oral traditions, in the folklorism of the popular songbook, in the *forrós*, in mediatized regional music, as well as in the new globalized expressive tendencies.

In their practice, these elements of language transcend the universe of a supposed cultural practice isolated in itself, to reveal that one and the same performer can dialogue expressively with various other musical practices.

This interface element reveals itself as a tensional or border area that allows solidary forms of interaction, integration, or communication, constituting something that serves as a reference for musical thought and performance. And in these terms, this procedure pointed to rhythm and the rhythmic dimension as important factors in how musicians and the local population manage to produce successful performances even in contexts not previously programmed.

The importance of this verification emerged from the concrete identification of an order of determinant values of the Indigenous matrix present as active vectors in the local culture. Whether expressed in playing, in singing, in dancing, and in other practices of everyday life, of speech, and of significant modes of musical thought.

Such an approach promotes a critical-reflexive decolonial reading of the problematic of Brazilian historiography, which little considers the contributions and markers of Indigenous identity in the construction of expressive musical thought in Brazil. And following this procedure, the present work sought to observe the use of the contrametric form 3+3+2 and its variants 2+3+3 or 3+2+3 as a common expressive resource present in the local sonic practice, proposing in its terminology the designation of the *perré* pattern as a marker of the expressive identity of Indigenous base in the oralized traditions in Pernambuco, its use having constituted a central line of musical thought in the expressive practices of oral tradition and mediatized practice.

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URBAN LAND REGULARIZATION – A CASE STUDY IN MOGI GUAÇU/SP

REGULARIZAÇÃO FUNDIÁRIA URBANA - ESTUDO DE CASO EM MOGI GUAÇU/SP

REGULARIZACIÓN DE LA TENENCIA DE LA TIERRA URBANA – ESTUDIO DE CASO EN MOGI GUAÇU/SP



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ABSTRACT

With population growth, the number of irregular land subdivisions has increased considerably, owing to the formation of subnormal housing, such as *favelas*, but also to a segment of the informal market: clandestine allotments (*loteamentos clandestinos*). The irregular occupation of land brings problems that are reflected in the other areas of service provision of a city; in addition to generating problems for the regularization of land tenure and, consequently, for the right to housing. In order to ensure the constitutional right to housing, as well as its regularization, Brazilian legislation establishes public policies aimed at ensuring these rights. This work presents a case study of urban land regularization, describing the procedures for preparing a regularization project in a clandestine urban settlement in the Municipality of Mogi Guaçu – SP. The data were obtained from an on-site survey (*in loco*) of the existing situation of the location, from municipal proceedings, and through the use of software such as Métrica Topo, Google Earth, and QGIS, and web portals such as DataGeo, for the preparation of the technical documents. With the data collected, the necessary steps for the land regularization procedure were established through the application of the federal law in force, from the first steps to the delivery of the regularization certificate to each landholder (*posseiro*). It was concluded that, with the application of the current Law, there is the possibility of guaranteeing the titling of the property for its occupants and the integration of the informal urban settlement into the urban territory, thus ensuring access to public services that were previously nonexistent.

Keywords: Land Subdivision. Irregular Subdivisions. Reurb.

RESUMO

Com o crescimento populacional, o número de parcelamentos de solo irregular teve um elevado aumento, devido a formação de habitações subnormais, como as favelas, mas, também, a um segmento do mercado informal que são os loteamentos clandestinos. A ocupação irregular do solo traz problemas que refletem nas demais áreas de prestação de serviço de uma cidade; além de gerar problemas para a regularização da posse do

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terreno e consequentemente o direito à moradia. Afim de assegurar o direito constitucional à moradia, bem como sua regularização, a legislação brasileira estabelece políticas públicas que visam assegurar esses direitos. Este trabalho apresenta um estudo de caso de regularização fundiária urbana, descrevendo os trâmites para a elaboração de um projeto de regularização em um núcleo urbano clandestino no Município de Mogi Guaçu – SP. Os dados foram obtidos a partir de levantamento *in loco* da situação existente do local, de processos municipais e com uso de *softwares* como o Métrica Topo, Google Earth, QGIS e portais *web* como o DataGeo, para elaboração das peças técnicas. Com os dados levantados foi estabelecido quais seriam os passos necessários para o procedimento de regularização fundiária por meio da aplicação da lei federal vigente, desde os primeiros passos até a entrega da certidão de regularização para cada posseiro. Concluiu-se que com a aplicação da Lei atual, há a possibilidade de garantia da titulação do imóvel para seus ocupantes e a integração do núcleo urbano informal ao território urbano, garantindo assim acesso aos serviços públicos antes inexistentes.

Palavras-chave: Parcelamento de Solo. Parcelamentos Irregulares. Reurb.

RESUMEN

Con el crecimiento poblacional, el número de parcelaciones de suelo irregulares ha experimentado un elevado aumento, debido a la formación de viviendas subnormales, como las *favelas*, pero también a un segmento del mercado informal que son las parcelaciones clandestinas (*loteamientos clandestinos*). La ocupación irregular del suelo trae problemas que se reflejan en las demás áreas de prestación de servicios de una ciudad; además de generar problemas para la regularización de la posesión del terreno y, en consecuencia, para el derecho a la vivienda. A fin de asegurar el derecho constitucional a la vivienda, así como su regularización, la legislación brasileña establece políticas públicas orientadas a asegurar estos derechos. Este trabajo presenta un estudio de caso de regularización de la tenencia de la tierra urbana, describiendo los trámites para la elaboración de un proyecto de regularización en un núcleo urbano clandestino en el Municipio de Mogi Guaçu – SP. Los datos se obtuvieron a partir de un levantamiento *in situ* (*in loco*) de la situación existente del lugar, de procesos municipales y mediante el uso de programas informáticos como Métrica Topo, Google Earth y QGIS, y de portales *web* como DataGeo, para la elaboración de las piezas técnicas. Con los datos recopilados se estableció cuáles serían los pasos necesarios para el procedimiento de regularización de la tenencia mediante la aplicación de la ley federal vigente, desde los primeros pasos hasta la entrega del certificado de regularización a cada poseedor (*posseiro*). Se concluyó que, con la aplicación de la Ley actual, existe la posibilidad de garantizar la titulación del inmueble para sus ocupantes y la integración del núcleo urbano informal al territorio urbano, garantizando así el acceso a servicios públicos antes inexistentes.

Palabras clave: Parcelación del Suelo. Parcelaciones Irregulares. Reurb.

1 INTRODUCTION

The urbanization process, for Roque and Ayoub (2020), occurs through the opening of lots within the urban perimeter and/or outside it, with the carrying out of the technical and legal procedure known as Land Subdivision (*Parcelamento de Solo*).

Land subdivision may be considered the main instrument for structuring urban space, since, according to Mesquita (2008), after its implementation the space created by it will maintain its structure for many years or centuries and will be occupied by various generations of city inhabitants. Thus, for Alvarenga (2007), urban land subdivision deals with the division of the land, in the form of allotments (*loteamentos*) and dismemberment (*desmembramento*). The subdivision is carried out by private initiative, under the supervision of the Public Administration.

The opening of allotments is the most common and significant form of urbanization in Brazil. Leonelli (2010) points out that Brazilian cities expand through the production of lots, in a constant transformation of rural areas into urban ones.

The technical and legal regulation of land subdivision is carried out through urban-planning legislation. Within the universe of urban-planning laws, Barreiros and Abiko (1998) asserted that Federal Law No. 6.766 (BRASIL, 1979) [[nota: números de leis brasileiras mantidos no formato original (com ponto), por serem identificadores de referência; ex.: 6.766, 13.465]] stands out, first because it is the law of national scope that provides for urban land subdivision and, second, for establishing norms and parameters that came to guide and determine new postures in state and municipal legislation.

This law, according to Freitas (2000), in addition to dismemberment, contemplates the allotment, whose execution proves more frequent and of greater impact, since the allotted tract (*gleba*) loses its objective individuality, transforming itself into streets, public spaces, and lots. The lots, for Queiroga (2002), come to have an autonomous life, transmuting themselves into "units autarkically sufficient in themselves," and must have direct access to the circulation routes created by the detailing of the tract.

Federal Law No. 6.766 (BRASIL, 1979) determines that the entire process of project development, legal authorization of the enterprise, and execution of the minimum infrastructure works of the subdivision for the commercialization of the lots is the full responsibility of the developer. Oliveira (2017) states that it is always important to emphasize that the non-fulfillment of any one of these stages is a crime, with penalties provided for in the referred law, which comprehensively outlines all the rules applicable to subdivision projects, such as: project configuration, urban-planning indices, basic infrastructure, documentation, guarantees, registry, contractual, and penal aspects, among others.

Despite this federal law, Conceição and Souza (2018) state that only in 2009 did a legal instrument come to address the question specifically and define the concept of land regularization as: the set of legal, urban-planning, environmental, and social measures aimed at the regularization of irregular settlements and at the titling of their occupants, in order to guarantee the social right to housing. This is undoubtedly the most important milestone of urban land regularization (Reurb): Federal Law No. 11.977 (BRASIL, 2009).

When the subdivision is executed without observance of the legal requirements, it may be considered clandestine or irregular. Lobo (2019) presents that the subdivision termed clandestine is one whose existence is not known to the competent Public Authority, or one that, although brought to the public authority for approval, has no such approval—that is, the request is denied or there is no application for approval at all. The irregular subdivision, in turn, is one in which there is knowledge and/or approval of the allotment project, but the execution of the subdivision is in nonconformity with the act of approval or with the legislation in force.

The disorderly occupation of land, for Freitas (2000), gave rise to the formation of subnormal housing, such as *favelas*, but also to a segment of the informal housing market that continues to grow, consuming the savings of the unwary, degenerating the urban development standards of cities, and often degrading the natural environment: the clandestine allotments.

According to Pinto (2003), clandestine allotments may be promoted both by the owners of the land and by third parties. In the first case, the aim is to escape the procedures and burdens contained in federal, state, and municipal laws, such as the allocation of public areas and the carrying out of infrastructure works. In the second, it is a matter of so-called land "grilagem" (land grabbing through fraudulent titles) [[nota: "grilagem" é termo jurídico brasileiro para apropriação de terras mediante falsificação de títulos; traduzido com glosa entre parênteses]], in which unscrupulous people sell land belonging to others as if it were their own.

Roque and Ayoub (2020) state that such allotments opened clandestinely become a problem for their purchasers and for municipal public managers, thus requiring their regularization after installation; however, Caldas (2009) emphasizes that the procedure for regularizing clandestine and/or irregular allotments is complex, costly, and slow, and at times conflictual.

Among other disturbances caused by the irregular occupation of urban land, Pinto (2003) highlights the following: disarticulation of the road system, hindering the access of buses, ambulances, police vehicles, and garbage collection trucks; formation of

neighborhoods subject to erosion and flooding, silting of rivers, lakes, and seas; absence of public spaces for the implementation of health, education, leisure, and security facilities; compromising of water supply sources and of the water table; clandestine electricity connections, resulting in risks of accidents and fires; excessive horizontal expansion of the urban fabric, causing high burdens on the public budget.

Informal real-estate transactions of unregistered properties do not generate tax revenues for states and municipalities. Roque and Ayoub (2020) observe that the Tax on the "Inter Vivos" Transmission of Real Property and of Real Rights over Real Property (ITBI – *Imposto sobre Transmissão "Inter Vivos" de Bens Imóveis e de Direitos Reais sobre Imóveis*) [[nota: sigla ITBI mantida; expansão e tradução do termo entre parênteses, conforme regra 5]], of municipal competence and which excludes transactions involving unregistered properties, was responsible for collecting around 9 billion reais in the country in 2013, which represented around 10% of the total tax revenues of Brazilian municipalities (FNP, 2014), which reinforces the need for allotments to become regular with the municipalities.

The irregularity of urban occupations, for Ribeiro (2018), shows itself to be a structural problem, demanding the promotion of public policies and legislative solutions so that the administration of this enormous contingent of people in a condition of irregular housing can be carried out. As a form of response to such a question, Federal Law No. 13.465 (BRASIL, 2017) brings the institute of Urban Land Regularization (Reurb), whether of social interest or not, in which the aim was to overcome the obstacles of previous legislation, attributing greater responsibility to the State and extending the list of those legitimated to request the project.

Urban Land Regularization (REURB) is presented by Maux (2017) as the processing that involves legal, urban-planning, environmental, and social norms with the purpose of incorporating informal urban settlements into the urban territorial ordering and of titling their occupants. The legal measures refer to the solution of tenure (*dominial*) problems, regarding situations in which the occupant of a public or private area does not hold a title with due legal guarantee over their occupation.

Ávila and Ferreira (2016) highlight that Provisional Measure No. 759 (BRASIL, 2016), converted into Federal Law No. 13.465 (BRASIL, 2017), provides for, highlights, and orders forms of Land Regularization through two models named: REURB-S, treatment as Social, for those verifiably qualified as Low Income, whose responsibility falls to the municipalities; and REURB-E, treatment as Specific, for those who do not fit the previous principle, whose responsibility falls to whoever has the established right—whether through proof of ownership or by court order—to fulfill and execute all the legal principles necessary for the regularization.

Melem and Santos (2021) explain that, in the case in which the irregular settlement, as ascertained by the socioeconomic survey, is inhabited by residents whose possessor/holder of the property has an income higher than 5 minimum wages—that is, if half plus one of the "heads of household" who possess the properties have a verified income higher than the maximum ceiling of 5 minimum wages—it is defined that the solution will be the application of the Reurb of Specific Interest (REURB-E). On the other hand, likewise ascertained by the socioeconomic survey, if the total quantity of possessors/holders of the existing properties within the area to be regularized exceeds half plus one of the properties inhabited by residents with an income lower than 5 minimum wages, we have the legal configuration for the application of the Urban Regularization of Social Interest (REURB-S), which exceptionally may be applied in informal urban settlements that occupy Permanent Preservation Areas (*Áreas de Preservação Permanente*), unlike Reurb-E, which, in the terms of Law No. 13.465 (BRASIL, 2017), brings no legal provision for such a procedure.

In this context, Conceição and Souza (2018) state that the text of the Law chose the socioeconomic criterion as the preponderant variable in defining which modality of Reurb will serve a given informal urban settlement. That is, the one who defines whether the regularization is of social or specific interest is the municipality, through an act of the executive, based on the socioeconomic condition, which must be assessed by means of a survey.

Despite this, Marrara (2019) stresses that irregular occupations must not be confused with urban land regularization for the needy population. The legislative, theoretical, and practical concern with regularization has increased, since irregular or clandestine occupations of public and private areas, besides resulting from pressing social needs, are also practiced by the middle and upper classes, as well as by economic agents of different sectors. Thus, a high volume of these occupations stems from the desperation of a good part of the Brazilian population, deprived of the minimum financial conditions to access dignified housing spaces and maintain them—not forgetting that a portion of these irregular occupations emerges as a malicious strategy of certain privileged social and economic groups, who employ it with the aim of enriching themselves improperly through the illicit appropriation of public or private goods outside the regular processes of subdivision and of acquisition of possession or ownership.

Melem and Santos (2021) present that, in order to request REURB, the following are legitimated: the Union, the States, the Federal District, the Municipalities, entities of the indirect public administration; its beneficiaries, housing cooperatives, residents' associations, foundations, social organizations, civil society organizations of public interest or other civil

associations; the owners of land, allottees, or developers; the Public Defender's Office (Defensoria Pública) and the Public Prosecutor's Office (Ministério Público). Marrara (2019) points out that Federal Law No. 13.465 (BRASIL, 2017) shifted to the Municipalities, and to the Federal District, the central role in conducting the regularization process. It also defined a legal regime of its own, seeking to congregate the acts in the hands of a single federative entity, with expectations of imparting greater speed to the conduct and conclusion of the regularization. As the process will occur in the Municipality where the area subject to regularization is located, the proximity between the parties and the public institutions tends to increase, so as to facilitate relations, the delivery of documentation, and the resolution of any conflicts, including by amicable and consensual settlement.

Jesus (2018), analyzing the legal provisions of Law No. 13.465 (BRASIL, 2017) and of Decree No. 9.310 (BRASIL, 2018), verifies concerns of a technical engineering order, tied to surveying and legal monitoring capable of identifying the parties directly involved in the Regularization process.

As for the regularization project, Conceição and Souza (2018) reaffirm that, with the provisions of the new Law, the process must be carried out under a georeferenced survey, a topographic survey, a planialtimetric cadastral survey, and a perimeter plan, and the provision of urban-planning demarcation became a non-mandatory figure. Furthermore, the land regularization project must consider the characteristics of the occupation and of the occupied area in order to define specific urban-planning and environmental parameters, in addition to identifying the lots, the circulation routes, and the areas intended for public use, when applicable.

The law also determines, according to Oliveski *et al.* (2018), the setting of a temporal milestone for purposes of land legitimation—that is, property occupied up to the date of December 22, 2016 may be regularized, without requiring a minimum time of occupation of the area or a linking of its use to housing, it being even permitted for commercial purposes, which may represent a reward for clandestine or illicit occupations.

According to Jesus (2018), Decree No. 9.310 (BRASIL, 2018) established, in its Article 21, that the process will follow these phases: request of the legitimated parties; administrative processing of the request, in which a period will be granted for the manifestation of the holders of real rights over the property and of the abutting owners; preparation of the land regularization project; remediation of the administrative process; decision of the competent authority, by means of a formal act to which publicity will be given; issuance of the Land Regularization Certificate (CRF – *Certidão de Regularização Fundiária*) [[nota: sigla CRF mantida com expansão e tradução, conforme regra 5]] by the Municipality or by the Federal

District; registration of the CRF and of the approved land regularization project at the real-estate registry office in which the real-estate unit with regularized urban purpose is located.

After the submission of the written regularization request, Marrara (2019) states that it will be up to the responsible local body to decide whether or not to receive it. As the restrictive administrative act that it is, the decision to deny receipt of the request must be substantiated with true and correct factual and legal grounds. In addition, it will contain the indication of the measures that must be adopted by the applicant with a view to the reformulation and reassessment of the request, when it has correctable flaws (Art. 32, sole paragraph).

At this stage, Jesus (2018) notes that the regularizing entity or interested party will take to the registry official the registrations of the CRF and of the approved land regularization project; should the official refuse, he must issue a substantiated note of the reasons that led to the refusal, in accordance with Article 40 of Decree No. 9.310 (BRASIL, 2018).

Marrara (2019) states that the approval of the request and the issuance of the CRF do not conclude the urban land regularization. Once the administrative-process phase within the competent municipal body is finished, it will be up to the applicants to collect the certificate and forward it to the local Real-Estate Registry Office for the due measures, beginning the second phase. After the CRF is registered, Jesus (2018) situates that a registration record (*matrícula*) will be opened for each of the regularized real-estate units, thereby initiating the full recognition of ownership for the mere possessor of the property; all these acts referred to in the law aim at the legitimacy and support of the entire procedure, since it allows interested parties, owners, and even abutting owners to manifest themselves regarding their rights, opening room for the remediation of possible irregularities and defining the Municipality as the holder for sending the Land Regularization Certificate to the real-estate registry office.

It is unquestionable, therefore, for Olivieski *et al.* (2018), that the new law is considered yet another important step in the legal framework of urban land regularization, since Reurb is a legal instrument of urban policy, a set of general norms and procedures encompassing legal, environmental, urban-planning, and social measures, with a view to removing certain urban settlements and their occupants from informality.

In view of the above, grounded in legislation, the objective of the work was to structure the process of application of Federal Law No. 13.465 (BRASIL, 2017), known as REURB, which deals with land regularization, obtaining and presenting all the steps necessary for the execution of this process, based on a case study in the city of Mogi Guaçu – SP.

2 MATERIALS AND METHODS

This work presented a study on the application of the Reurb-E Law in a case study, in which the necessary stages were addressed—the administrative process, the request of the legitimated party, and the technical process—for the development of the entire process of regularizing an area that is irregular according to the legislation in force. Such an area is located in the municipality of Mogi Guaçu – SP and is named "Chácara Santa Rita," with a total of 35 lots implemented irregularly.

For the preparation of the study, satellite images obtained from the Google Earth software (GOOGLE EARTH, 2021) were used, along with documents and technical pieces from the company responsible for the regularization process, documents from different bodies of the municipal government, and inputs and edits in the software Métrica Topo, QGIS 3.18, and the web portal Sigam Datageo and the IGC geoportal.

3 RESULTS AND DISCUSSION

3.1 STUDY AREA

The study area for the application of the Reurb was located in the municipality of Mogi Guaçu, State of São Paulo, Brazil (**Figure 1**), with coordinates of latitude 22°22'15" South and longitude 46°56'38" West, with an approximate population of 153,033 inhabitants according to the IBGE (2020).

Figure 1

Location map of the municipality of Mogi Guaçu



Source: ROQUE; AYOUB (2020).

The study area was chosen owing to the allotter's interest in regularizing this clandestine urban settlement, since there is already a process under way, which served as the basis for the present study.

This area is a clandestine allotment named "Chácara Santa Rita," located in the Engenho Velho neighborhood on the SP-342 Highway, with coordinates of latitude 22°18'08.6" South and longitude 46°54'19.5" West, 8.6 km from the center of Mogi Guaçu –

SP, containing 35 lots of at least 1,000.00 m² and implemented clandestinely, given that at the time of its implementation the norms in force for execution and regularization were not followed. The clandestine land subdivision, as Lobo (2019) explains, is one whose existence is not known to the competent Public Authority, or for which approval does not exist—that is, the request is denied or there is no application for approval.

The allotment that is the object of study, as per the images presented in Figure 2, has been in a situation of irregularity since before April 2006, possessing the same constructive and territorial-occupation characteristics for more than 15 years.

Figure 2

LOCATION OBJECT OF THE STUDY, BEING (A) IMAGE FROM APRIL 2006 AND (B) IMAGE FROM AUGUST 2021

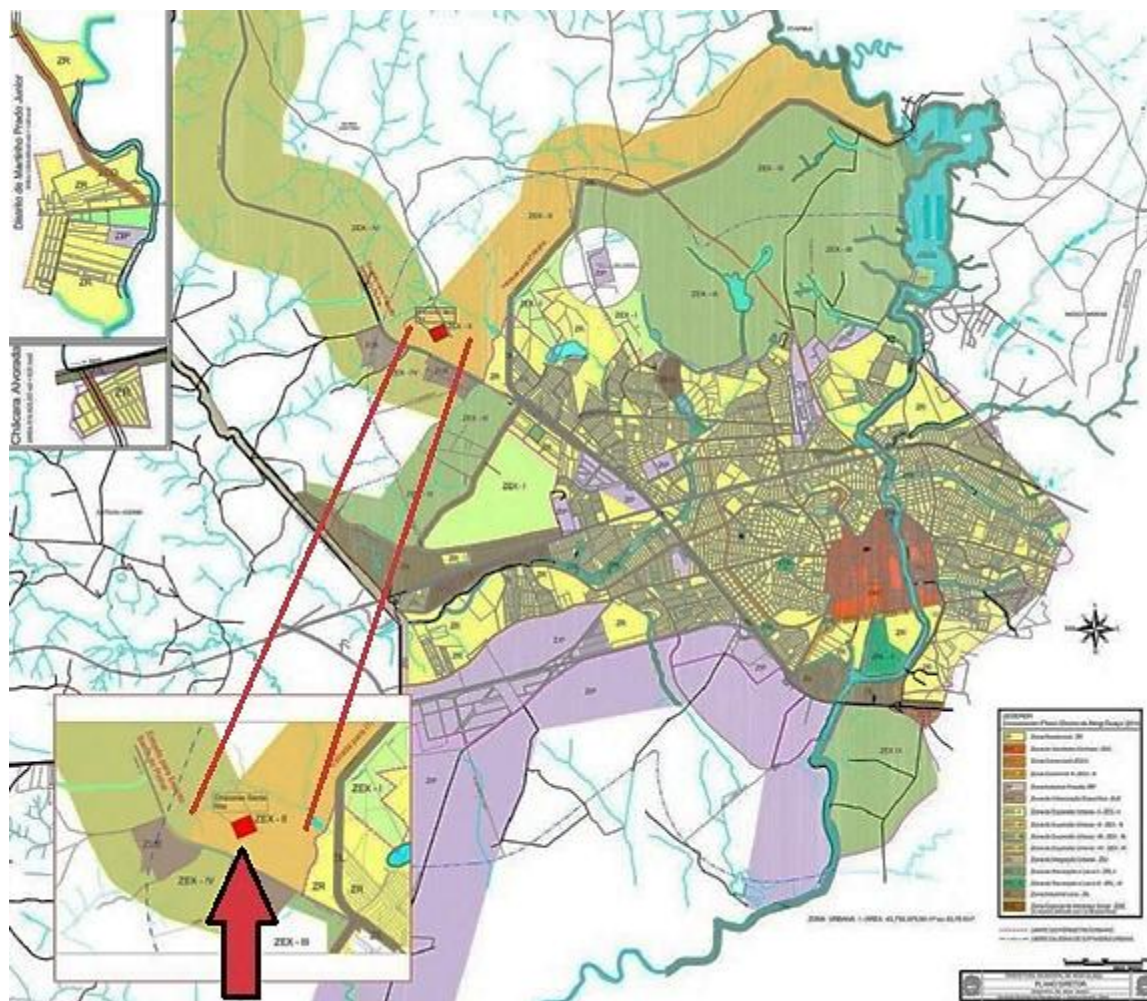


Source: Google Earth (2021).

In accordance with Municipal Complementary Law No. 1.291 (MOGI GUAÇU, 2015a), which deals with the Master Plan (*Plano Diretor*) of the city of Mogi Guaçu, and Complementary Law No. 1.415 (MOGI GUAÇU, 2021b), which provides for the zoning and land-use plan of the municipality of Mogi Guaçu, it can be verified that the area that is the object of this study is located in the Urban Expansion Zone named "ZEX – II" (**Figure 3**), which are the areas intended for urban expansion beyond the official urban perimeter and which, therefore, possess differentiated urban-planning characteristics, in order to better order the occupation.

Figure 3

ZONING MAP OF THE CITY OF MOGI GUAÇU/SP, HIGHLIGHTING THE LOCATION OF THE OBJECT OF STUDY



Source: Adapted from the zoning and land-use plan of the Municipality of Mogi Guaçu (2021).

3.2 ADMINISTRATIVE PROCESS

The administrative process for carrying out the regularization through the Reurb is regulated in Art. 28 of Federal Law No. 13.465 (BRASIL, 2017), where it will have the following phases: the request of the legitimated parties, classification of the area, preparation of the regularization project, municipal decision, and issuance and registration of the CRF with the real-estate registry office.

3.2.1 Request of the legitimated parties

The first stage of the regularization process is the request of one of the legitimated parties established in Article 14 of Federal Law No. 13.465 (BRASIL, 2017). In this case, the request was prepared by the allotter of the property before the city government, on December

4, 2017, requesting the regularization of the informal urban settlement named "Chácaras Santa Rita."

After the regularization request is submitted, it will be up to the municipality to decide whether or not to accept it. However, as Marrara (2019) cites, in the case of a refusal by the city government, this decision must be substantiated with true and correct factual and legal grounds, in addition to the indication of the measures that must be adopted by the applicant with a view to the reformulation and reassessment of the request, when it has correctable flaws.

As analyzed by Ribeiro (2018), the Reurb, as provided for by Federal Law No. 13.465 (BRASIL, 2017), proposes the regularization of consolidated informal urban settlements, whether large or small, in a unified manner, through a single project for each area. Therefore, regardless of the purpose of the clandestine allotment, the regularization process is applicable, provided that it fits the requirements established in the Law and in the municipal guideline.

To regulate the regularization process and standardize all the procedures, Decree No. 9.310 (BRASIL, 2018) was instituted, establishing the general norms applicable to Urban Land Regularization and setting the procedures for the appraisal and disposal of properties of the Union.

Thus, it was stipulated that the regularization would occur through two types of regularization, which are regulated according to the social characterization that they fit. The typification of the Reurb occurs in two models: Reurb-S and Reurb-E. Reurb-S, known as Land Regularization of Social Interest, is applied when the predominance of the population of the clandestine urban settlement is low-income, being so considered through the Municipal Government. Clandestine urban settlements typified as Reurb-S are exempt from paying the costs of the regularization process, with the entire regularization process—from the preparation of the necessary projects to the existing expenses—falling to the public authority.

Reurb-E, known as Land Regularization of Specific Interest, is applied to persons who do not fit as low-income; therefore, if classified in this modality, those who must bear the costs of the regularization process are the owners.

As for the modality of Reurb to be adopted, as Jesus (2018) cites, the classification of the Reurb modality that will be adopted falls to the municipal executive authority, there being no reason for the official of the real-estate registry office or any other authority to contest the modality used.

According to the return note from the city government on December 6, 2018, the clandestine urban settlement on which this study is based was classified as Reurb-E, since,

after analysis of documents by the city government, divergences of the clandestine allotment from the legislation that approves allotments were verified.

It is important to highlight that the land regularization process often occurs owing to a pressure external to the owners, as occurred with the object of study in question, in which there is a Conduct Adjustment Agreement (TAC – *Termo de Ajustamento de Conduta*) [[nota: sigla TAC mantida com expansão e tradução, conforme regra 5]], in a public civil action, placing on the owner the accountability for the regularization.

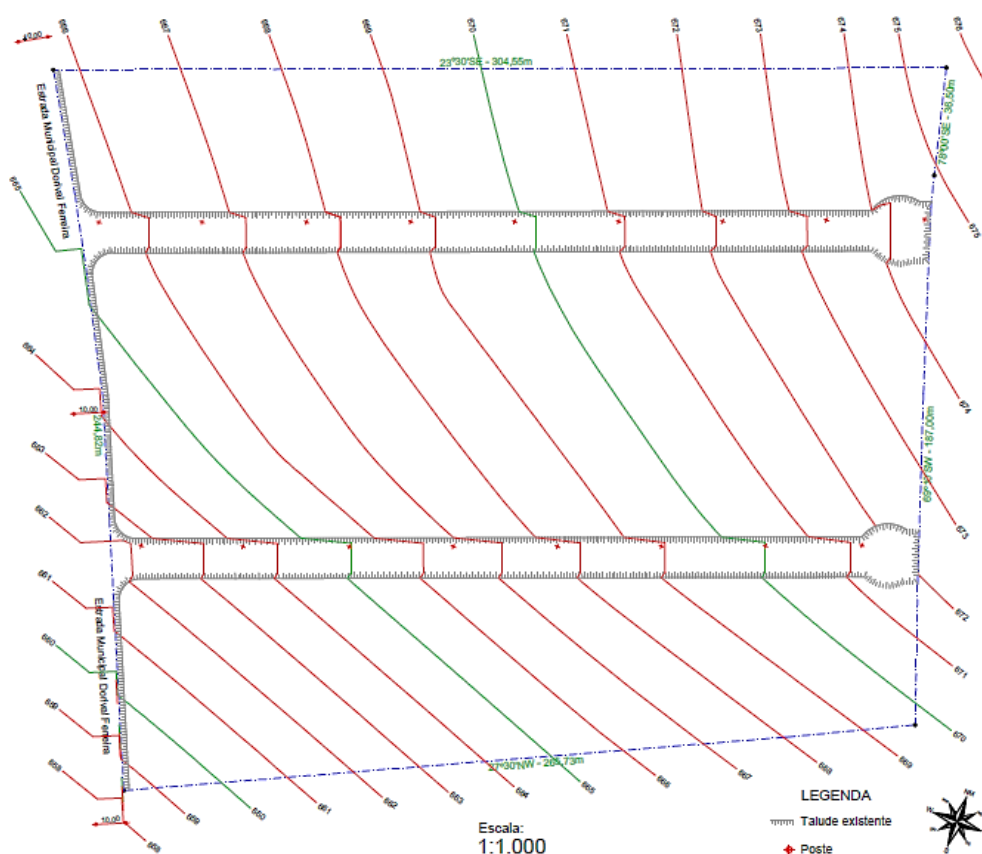
3.3 TECHNICAL PROCESS

The land regularization process continues with an administrative process containing the technical pieces that support the analysis by the public authority as to compliance with the laws and norms of the minimum structures required.

The first of these is the planialtimetric survey to support the initial analyses of the location of the lots and the runoff of rainwater, as well as of structures for managing precipitation, as presented in Figure 4, accompanied also by a location plan of the enterprise over an image, and the project for paving and gravel of the carriageways.

Figure 4

PLANIALTIMETRIC SURVEY

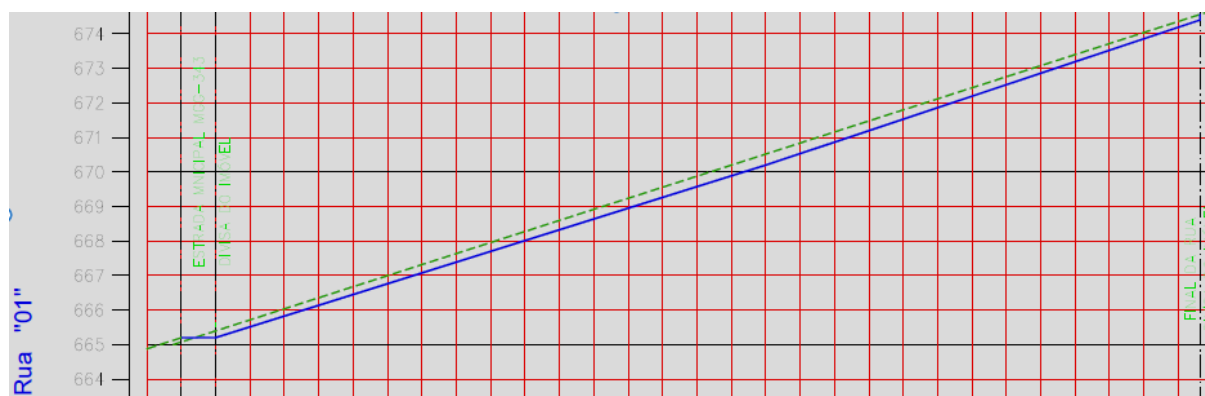


Source: technical pieces of the administrative process, 2020.

It is important to emphasize that each existing street within the allotment must be presented with its respective profile project, as presented in Figure 5 for one of the internal axes of the property.

Figure 5

LONGITUDINAL PROFILE OF "STREET 01," IN THE NORTHERN PART OF THE PROPERTY, WITH ITS RESPECTIVE ELEVATIONS ON THE X-AXIS AND HORIZONTAL DISTANCE ON THE Y-AXIS



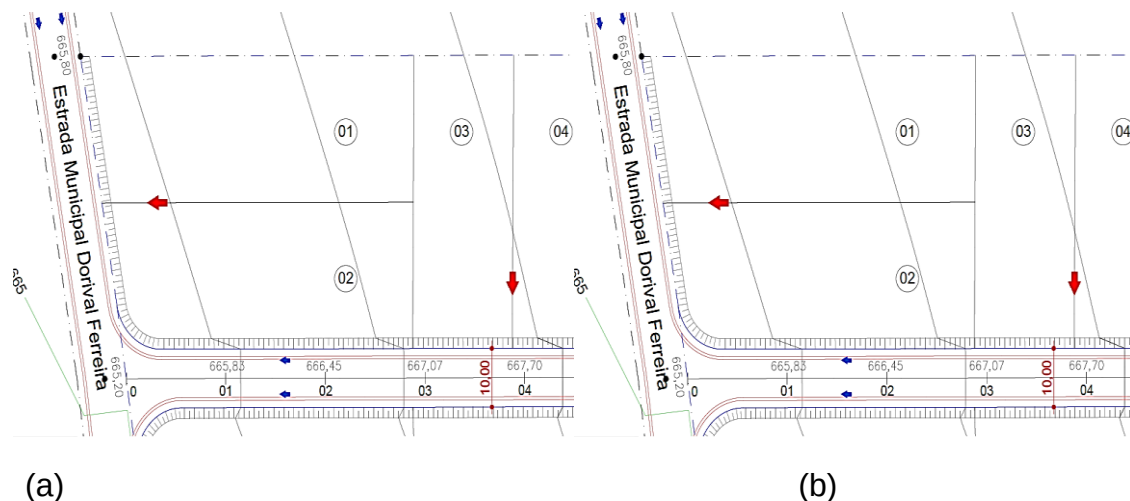
Source: technical pieces of the administrative process, 2020.

With staking every 10 meters, the first 160 meters have a slope of 3.13% and the final 126.28 meters a slight increase in slope, to 3.33%, a fact that is repeated for the other existing internal axis. The presentation of maps that allow the correct analysis by the technical team of the municipal government is important to highlight.

The Earthwork and Urban-Planning projects are fundamental for the analysis of the distribution of the existing lots in relation to the direction of drainage of the blocks and streets, the channels existing on the streets, green areas, areas for urban and community facilities, the dimensions involved, and the abutting properties (**Figure 6**).

Figure 6

INITIAL PROJECTS PRESENTED FOR REGULARIZATION, BEING (A) DETAIL OF THE EARTHWORK AND DRAINAGE PROJECT, WITH THE DIRECTION OF DRAINAGE AND SLOPES, AND (B) DETAIL OF THE URBAN-PLANNING PROJECT CONTAINING AN AREA FOR COMMUNITY FACILITIES



Source: technical pieces of the administrative process, 2020.

The base project and calculation memorandum for defining the destination of the liquid effluents of the allotment lie in the sanitation and sewage project. As the irregular allotment that is the target of the present research is far from the public sewage collection network, it was opted to design cylindrical septic tanks, anaerobic filters, and cylindrical soak pits (*sumidouros*) for the treatment of domestic effluents, individually, in accordance with NBR 13.969 (ABNT, 1997).

The useful volume of each septic tank is given by **Equation 1**.

$$V = N \times [C \times T + (K \times Lf)] \text{ (Equation 1)}$$

Where: V = useful volume (in liters); N = number of contributors (5 inhabitants adopted); C = daily contribution of waste (150 liters/person/day); T = hydraulic detention time of sewage in the tank (1 day); K = accumulation rate (57); Lf = per capita contribution of fresh sludge (1 liter/person/day). With a result of 1,035 liters or 1.035 m³, a volume of 1.19 m³ was therefore adopted for the septic tank, which will be designed with a depth of 1.25 meters and a diameter of 1.10 meters.

The anaerobic filter, which consists of a biological reactor where the sewage is purified by means of facultative and anaerobic microorganisms responsible for the stabilization of the organic matter, is given by **Equation 2**.

$$V_u = 1.6 \times N \times C \times T \text{ (Equation 2)}$$

Where: V_u = useful volume of the filter (in liters); N = number of contributors (5 people); C = contribution of waste (150 liters/person/day); T = detention period (1 day). With a result of a useful volume of 1,200 liters or 1.200 m³; and, for the biological filter, the limit height of the filter bed is 1.20 meters, already including the height of the false bottom, which must be limited to 0.60 meters, already including the thickness of the slab; therefore, a volume of 1.71 m³ was adopted for the anaerobic filter, which will be designed with a useful height of 1.80 meters and a diameter of 1.10 meters.

For the sizing of the soak pits, the final stage of effluent treatment, infiltration tests were carried out through cylindrical pits, with the aid of an auger. After the tests, a soil infiltration coefficient on the order of 52 L/m² was determined. Adopting a maximum daily flow on the order of 1.00 m³/day for each residence, **Equation 3** was used.

$$A_{i_soak\ pit} = (V_c / C_i) \text{ (Equation 3)}$$

Where: $A_{i_soak\ pit}$ = internal area of the soak pit (m²); V_c = contribution volume (m³ × day); C_i = soil infiltration coefficient (liters/m²). With a result of an infiltration area of 19.23 m², and adopting a cylindrical soak pit with a diameter of 2.00 m and a useful height of 2.60 m, an infiltration area of 19.48 m² is obtained, meeting the calculated value.

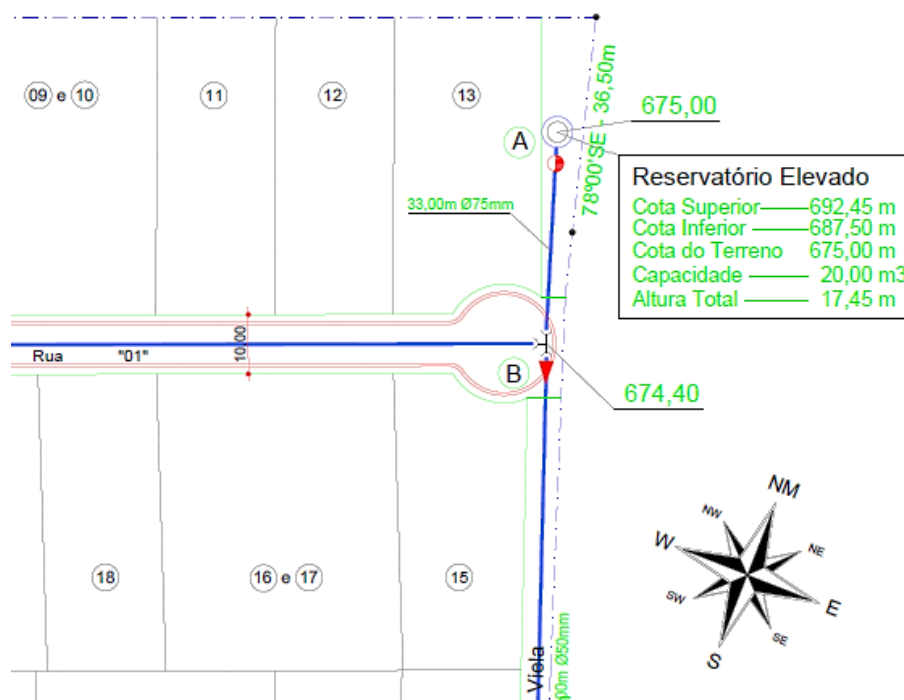
It is important to highlight the study by Santos and Roque (2017), in which they verified the nonexistence of these structures for the final destination of effluents in residential developments; even though there was a detailed scheme for the correct execution of the Septic Tank, filter, and soak pit, they concluded that basic sanitation is not a priority for professionals in the execution of works for which they are responsible. Thus reaffirming that, even if there are existing projects, as concluded by Reis *et al.* (2016), it is fundamental that the oversight bodies and the population in general pay attention to the correct destination of sanitary sewage, as well as ponder the importance of following the engineering projects approved by official bodies.

The last item to be part of the technical pieces in the regularization process is the potable water supply project. The calculation memorandum must present the sizing of the quantification of the set of pipes and accessories intended for the distribution of the potable water supply network to the entire allotment in a continuous and uninterrupted manner.

The potable water project must contain, in addition to the distribution of the necessary equipment, the total length of the distribution network, as shown in detail in Figure 7.

Figure 7

DETAIL OF THE POTABLE WATER PROJECT, SHOWING THE ACCUMULATION AND DISTRIBUTION POINT



Source: technical pieces of the administrative process, 2020.

It begins with the forecast of the resident population, as a function of the occupation area, in a total of 35 lots, and an average number of inhabitants per lot of 5 people, reaching 175 inhabitants, with a saturation population of the area (end of plan) equal to 200 inhabitants, using a project horizon with a forecast of saturation of the allotment of 20 (twenty) years. The water is intended exclusively for domestic use, comprising the following purposes: hygienic, alimentary, floor and clothes washing, garden watering, among others. The per capita water consumption (q) adopted was 250 liters/inhabitant/day, and the minimum dynamic pressure at the most unfavorable point will be 12 meters of water column (mwc).

For the calculation of the average project flow, **Equation 4** is used.

$$Q_m = q \times P / 86,400 \text{ (Equation 4)}$$

Where: Q_m = average flow (in liters); q = per capita consumption; P = saturation population. Reaching a value of 0.58 liters per second of necessary average flow. It then proceeded to the design flow (Q) using **Equation 5**.

$$Q = Q_m \times K_1 \times K_2 \text{ (Equation 5)}$$

Where: K_1 = daily variation adopted as the coefficient of the day of greatest consumption (1.20); K_2 = hourly variation adopted as the coefficient of the hour of greatest consumption (1.50). Reaching 1.04 liters per second, which will be the basis for the calculation of the distribution flow according to **Equation 6**.

$$Q_d = Q / l_t \text{ (Equation 6)}$$

Where: l_t = total length of the network (714.00 meters, obtained from the map in **Figure 7**). Reaching a distribution flow of 0.00146 liters per second for each meter of network. The capacity of the reservoir (C) was calculated by the method based on a consumption curve assimilated to a sine wave.

Where V is the volume of water consumed in 24 hours on the day of greatest consumption:

$$Q = 1.04 \text{ L} \cdot \text{s}^{-1} = 3.74 \text{ m}^3/\text{h} ; K_1 = 1.20 \quad V = 3.74 \times 24 \times 1.20 = 107.71 \text{ m}^3$$

The minimum capacity of distribution reservoirs for normal consumption, as a function of K_2 , is given by **Equation 7**.

$$C = 0.16 \times V \text{ (Equation 7)}$$

Reaching a reservoir volume of 17.24 m^3 , an elevated goblet-type (*taça*) reservoir was then adopted, with water in the column, of a capacity of 20 m^3 .

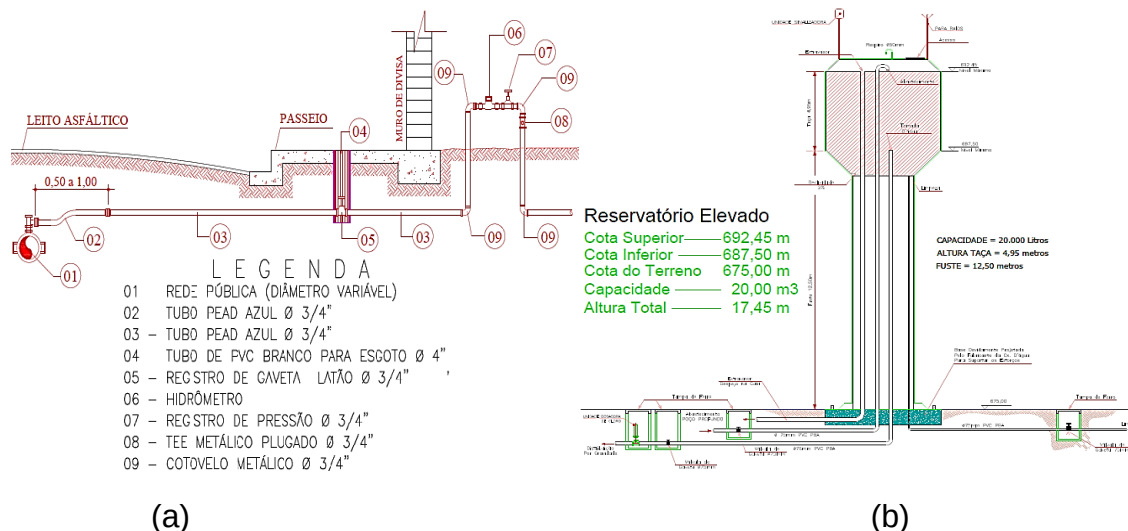
The basis for the correct distribution of water throughout the allotment is the calculation of the most unfavorable piezometric elevation, with the upstream end of section 4 being defined as the most unfavorable; its upstream piezometric elevation (C_{pj}) is calculated according to **Equation 8**.

$$C_{pj} = C_t + H + 12 \text{ (Equation 8)}$$

Where: C_t = terrain elevation (674.40 m); H = 0.108 (head loss); 12 mwc = (minimum dynamic pressure permitted in the network). Reaching a value of 686.51 meters, which is the basis for the calculation of the reservoir height; subtracting from the C_{pj} the terrain elevation of the reservoir (675.00 m), therefore, 11.51 m of height, the height of 12.50 m was then adopted, following the detailing of the reservoir presented in Figure 7, and the household connections presented, with piping in the water distribution network in rigid PVC PBA class 20 pipes.

Figure 8

Details of the household water supply connections (a), and the reservoir for the accumulation of water from a deep well, with respective connections and base (b).



Source: technical pieces of the administrative process, 2020.

With this set of technical pieces and the duly registered request, the irregular allotment is equipped with technical material to comply with the Reurb and is ready for the analysis by the public authority as to the technical procedure in the regularization process, with the issuance of the Land Regularity Certificate to the occupants qualified individually, according to the lots, for purposes of subsequent registration, with the official of the Real-Estate Registry Office responsible for the locality.

4 CONCLUSION

Federal Law No. 13.465 (BRASIL, 2017) brings a set of instruments that facilitate and allow the land titling of irregular allotments; however, because it is relatively recent legislation, many professionals still have problems in its conduct and execution, there being a deficiency in its technical application and in the legal conduct of the process. Nonetheless, as demonstrated in the present work, the process occurs within the municipal sphere and with technical pieces well known to the technical staff involved with land management.

The allotment that is the object of study, with a total tract area of 65,299.36 m², has been in a condition of irregularity for more than 15 years and finds in the current legislation the possibility of regularization and titling for the owners of the lots. The process must pay attention to the allocation of green areas, urban facilities, and community facilities as recommended in the legislation and in the municipal definitions, in accordance with the zones contained in the municipal master plan.

The classification as Reurb-E requires that the owner hire a professional accredited with the Regional Council of Engineering and Agronomy (CREA – *Conselho Regional de Engenharia e Agronomia*) [[nota: sigla CREA mantida com expansão e tradução, conforme regra 5]] to conduct the technical pieces and a lawyer to conduct the legal process.

It must be emphasized that the process does not end with the issuance of the CRF, there being a need for the owners of the lots to carry out registration with the Real-Estate Registry Office.

Irregular allotments are an old problem of the municipalities, and with the increase in real-estate speculation in peri-urban areas, they tend to increase, there being a constant need for public managers to monitor these processes of occupation of the territory and to make effective use of Federal Law No. 13.465 (BRASIL, 2017), ensuring the possibility of titling the property for its occupants and also the integration of the informal urban settlement into the urban territorial ordering, thus ensuring access to public services that were previously nonexistent.

It is hoped that the present work will shed light on the description of the process of regularizing a typically irregular allotment, these procedures being valid throughout the national territory, thus contributing to a greater popularization regarding the application of the legislation involved in the management of the territory.

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INDIVIDUAL PERFORMANCE EVALUATION INDICATORS IN TELEWORK AND BRAZILIAN LEGISLATION: A SYSTEMATIC LITERATURE REVIEW

INDICADORES DE AVALIAÇÃO DE DESEMPENHO INDIVIDUAL NO TELETRABALHO E LEGISLAÇÃO BRASILEIRA: UMA REVISÃO SISTEMÁTICA DA LITERATURA

INDICADORES PARA EVALUAR EL DESEMPEÑO INDIVIDUAL EN EL TELETRABAJO Y LA LEGISLACIÓN BRASILEÑA: UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA



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ABSTRACT

This article examines the performance indicators employed to assess telework in the Brazilian public administration, considering current legislation. Using the Systematic Literature Review (SLR) methodology, the study maps the main theoretical and regulatory contributions on the subject, highlighting challenges and gaps in practical implementation. The results show that the most frequently mentioned indicators relate to productivity, work quality, employee well-being, and cost-effectiveness. Brazilian legislation, in turn, emphasises objective and measurable goals, with a lesser focus on subjective aspects such as mental health and job satisfaction. The study concludes that, for telework to be consolidated as an effective management tool, it is essential to adopt more comprehensive evaluation systems that integrate performance results with quality of life and employee engagement.

Keywords: Telework. Telecommuting. Hibrid Work. Performance Evaluation. Indicators.

RESUMO

Este artigo identifica os indicadores de desempenho utilizados na avaliação do teletrabalho na administração pública brasileira, à luz da legislação vigente. Utilizando a metodologia de Revisão Sistemática da Literatura (RSL), são mapeadas as principais contribuições teóricas e normativas sobre o tema, destacando os desafios e lacunas na aplicação prática. Os resultados mostram que os indicadores mais recorrentes se referem à produtividade, qualidade do trabalho, bem-estar do servidor e economicidade. A legislação brasileira, por sua vez, foca em metas objetivas e mensuráveis, com menor ênfase em aspectos subjetivos como saúde mental e satisfação. Conclui-se que, para a consolidação do teletrabalho como ferramenta de gestão eficiente, é necessário adotar sistemas de avaliação mais abrangentes, que articulem resultados com qualidade de vida e engajamento.

Palavras-chave: Teletrabalho. Trabalho Híbrido. Avaliação de Desempenho. Indicadores.

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RESUMEN

Este artículo identifica los indicadores de desempeño utilizados en la evaluación del teletrabajo en la administración pública brasileña, a la luz de la legislación vigente. Mediante la metodología de Revisión Sistemática de la Literatura (RSL), se mapean las principales contribuciones teóricas y normativas sobre el tema, destacando los desafíos y las brechas en su aplicación práctica. Los resultados muestran que los indicadores más recurrentes se refieren a la productividad, la calidad del trabajo, el bienestar del empleado y la relación costo-efectividad. La legislación brasileña, a su vez, se centra en objetivos objetivos y medibles, con menor énfasis en aspectos subjetivos como la salud mental y la satisfacción. Se concluye que, para consolidar el teletrabajo como una herramienta de gestión eficiente, es necesario adoptar sistemas de evaluación más integrales que articulen los resultados con la calidad de vida y el compromiso.

Palabras clave: Teletrabajo. Trabajo Híbrido. Evaluación del Desempeño. Indicadores.

1 INTRODUCTION

The global landscape of work has been undergoing profound transformations, driven mainly by technological advances and, recently, by the contingencies imposed by the health crisis caused by the COVID-19 pandemic. In this context, telework emerged from an alternative modality into a consolidated practice, including in the public sector (Machado, Toledo, 2022; Baumann; Marcum, 2023; and Serpa, Guerra, Gonçalves, 2025).

Although research on remote work, often called "telework" or "work at a distance," has been a recurrent theme within management and organizational studies, it was the onset of the COVID-19 pandemic, accompanied by mandatory social-distancing measures, that elevated working from home to a common practice in most organizations. This paradigm shift imposed challenges on the structures, processes, and coordination mechanisms existing in organizations (Kraus; Ferraris; Bertello, 2023).

Historically, the Brazilian public administration has sought to improve its efficiency and effectiveness, adopting the precepts of managerial management that emphasize results orientation and performance evaluation (Bresser-Pereira, 1998). The implementation of telework in this environment, however, introduces new complexities for measuring the performance of public servants and the deliverables of organizations (Baumann, 2021). If, on the one hand, telework can promote greater autonomy, flexibility, reduction of operational costs, and better quality of life for public servants, on the other, it requires the readjustment of management, communication, and performance-evaluation processes (Vilarinho; Paschoal; Demo, 2020).

From this perspective, the need arises to identify and understand which performance indicators are used to evaluate telework in the Brazilian public administration. The academic literature, although growing, still seeks to consolidate models and metrics that consider the particularities of public service, such as the nature of the services provided, the tenure of the public servant, and the principles of legality, impersonality, morality, publicity, and efficiency (Bresser-Pereira, 1998). In parallel, Brazilian legislation has advanced in the regulation of telework in the public sector, establishing guidelines for its implementation, monitoring, and evaluation (MGI, 2025). Thus, understanding the convergence and the failures between theoretical propositions and legal norms is fundamental for the improvement of performance management (Baumann; Marcum, 2023).

Although the academic literature has been advancing toward a multidimensional perspective for performance evaluation in telework—articulating indicators of productivity and quality of deliverables, behavioral competencies, and dimensions of worker well-being and engagement (Caraiani et al., 2023; Müller, 2019; Radonić, 2021; McPhail et al., 2023)—the

Brazilian normative framework, embodied in Decree No. 11.072/2022 and in Normative Instructions No. 65/2020 and Joint SEGES-SGPRT/MGI No. 24/2023, is oriented predominantly by a pragmatic and quantitative logic, centered on the fulfillment of objective goals and measurable work plans.

This dichotomy between academic concepts and the operational rigor of the regulation in the public administration configures a research opportunity, insofar as investigations dedicated to examining how it is possible to reconcile the holistic and integrative approach proposed by the literature with the formal requirements and the institutional limits imposed by Brazilian legislation are still scarce—in order to build evaluation models that are, at the same time, technically robust, legally adherent, and sustainable from the standpoint of the quality of life and professional development of the public servant under a telework regime.

In view of the above, this article seeks to answer the following research question: "Which performance indicators have been proposed in the academic literature, and how does Brazilian legislation address the evaluation of telework in the public administration?"

To this end, the general objective of this study is to analyze the individual performance indicators for the evaluation of telework and to verify how they can be implemented in the Brazilian public administration, based on a systematic literature review.

The justification for this research lies between the rapid advance of telework in the public sector and the consolidation of methods for its evaluation (Kraus; Ferraris; Bertello, 2023). This study aims to contribute both to academia, by systematizing the available knowledge, and to the practice of public management, by providing input so that managers and public-policy makers can establish clearer evaluation criteria aligned with organizational objectives, enhancing the delivery of public value. The understanding of the indicators and of the legal basis can assist in strategic decision-making for the optimization of telework, ensuring that it translates into benefits for society, for public servants, and for the public service itself. This article is structured in five sections. After this introduction, Section 2 presents the theoretical framework, addressing concepts of telework, performance evaluation in telework, performance indicators, and a compilation of Brazilian legislation on telework. Section 3 details the systematic literature review methodology employed in the study. Section 4 offers a discussion of the findings, articulating the literature with the legislation. Finally, Section 5 presents the conclusions of the study, its contributions, and suggestions for future research.

2 THEORETICAL FRAMEWORK

Understanding the dynamics of telework and its performance evaluation, especially in the context of public administration, requires grounding in theoretical concepts that permeate both organizational management and the specificities of the public sector. This section addresses the foundations that underpin the discussion, beginning with the conceptualization of telework, moving through performance evaluation, gathering types of individual performance indicators, and ending with a compilation of Brazilian legislation on telework.

2.1 CONCEPTS AND MODALITIES OF TELEWORK

Telework, also known as remote work, work at a distance, or *home office*, refers to the modality of carrying out work activities outside the physical and traditional premises of the organization, with the use of information and communication technologies (ICTs) (McPhail, 2023). Although the concept is not new, its popularization and regulation in various countries, including Brazil, intensified significantly in recent decades.

Telework began to be outlined in the United States in the 1970s, motivated by factors such as the oil crisis, the growing problems of traffic and pollution in urban centers, and the expansion of female participation in the labor market. In this context, the modality emerged as a strategy to reduce commuting costs and optimize organizational resources, through the remote performance of work activities with the support of the communication technologies available at the time. The term telework was first used by the physicist Jack Nilles, questioning the fact that people needed to go to work instead of using the available technologies and working at home (Dupont; Giuliano; Godfroid, 2023). However, it was with the expansion of ICTs from the 1990s onward that telework spread significantly (Caraiani; Lungu; Dascalu; Stoian, 2023).

The terms telework, remote work, virtual work, part-time work, and work at home are related to work carried out outside traditional office spaces and to the delivery of activities, with an emphasis on flexibility (Soga; Bolade-Ogunfodun; Nasr; Laker, 2022). Telework can also be defined as an alternative form of work organization, made viable by the total or partial use of ICTs from the home or from remote locations (Radonić, 2021).

There are several modalities of telework, such as *home office*, where the worker performs their tasks predominantly at their residence; telework in remote/satellite centers, which occurs in decentralized offices or *coworking* spaces; mobile telework, characterized by location flexibility, where the worker moves about constantly, using technology to connect; and hybrid telework, which combines days of in-person work at the organization with days of

telework, being one of the most adopted modalities currently for offering a balance between flexibility and social interaction (Bloom; Ruobing; Liang, 2024).

The advantages of telework are widely discussed in the literature and include the reduction of operational costs for the organization (such as rent, building maintenance, energy, water, telephony, internet), greater flexibility and autonomy for the worker, a decrease in commuting time and cost, a potential increase in productivity (through the reduction of interruptions and optimization of time), and an improvement in quality of life. However, there are also disadvantages and challenges, such as the difficulty of supervision, the blurring of the boundary between personal and professional life, the risk of the worker's social isolation, the need for adequate and secure technological infrastructure, and the importance of an organizational culture that supports autonomy and trust (Behrens, 2024).

In view of these new, flexible, and dynamic work models, it became necessary to think of ways to improve performance management. This is considered a broad and continuous process of identifying, measuring, developing, and monitoring individuals and work groups, aligned with the strategic objectives of the organization. It allows workers to become more competent, committed, and motivated; facilitates organizational change; makes organizational objectives evident; and helps organizations make more assertive decisions (Aguinis, 2021). In this scenario, it becomes imperative to investigate and analyze individual performance evaluation, a preponderant stage in performance management.

2.2 PERFORMANCE EVALUATION IN TELEWORK

Individual performance evaluation in a telework environment demands distinct approaches compared with in-person work. The main change lies in the lower visibility of the work process and in the greater emphasis on results and deliverables. Traditionally, many evaluation systems in in-person models considered presence and observable behavior in the work environment. In telework, this becomes less relevant, and the measurement must focus on what is produced and on the delivery of activities (McPhail; Chan; May; Wilkinson; 2023).

The importance of focusing on *outputs* and *outcomes* for performance evaluation [stands out], especially in contexts in which direct supervision is reduced. For telework, this means that managers need to define clear and measurable goals, and public servants must have autonomy and resources to achieve them. Mutual trust between manager and public servant becomes a fundamental pillar (Aguinis, 2021).

Other specificities include the management challenge of measuring tasks that are not quantifiable, such as the quality of the deliverable and creativity. Telework requires greater self-discipline and responsibility from the public servant, and the evaluation system must

reflect this autonomy, focusing on accountability for the agreed-upon results. Performance evaluation must consider the teleworker's well-being and use indicators related to work-life balance and mental health. The physical distance requires a more structured communication and *feedback* plan to ensure that the teleworker is aware of their performance and of expectations. ICTs, which make telework viable, can also be tools for collecting performance-evaluation data, calculating response time, document delivery, and participation in virtual meetings (Kuruzovich, 2021).

Given the challenges inherent to individual performance evaluation in telework—such as the reduced visibility of the work process and the need to prioritize *outputs* and *outcomes*—it becomes important to redefine the evaluation criteria (McPhail et al., 2023; Aguinis, 2021). The emphasis on tangible results, combined with the consideration of qualitative dimensions (well-being, work-life balance) and the strategic use of ICTs, requires indicators capable of capturing this complexity (Kuruzovich, 2021). It is in this context that the discussion on individual performance evaluation indicators gains centrality. As evidenced by Vos and Voordt (2002) and McCloskey (2003), the distinction between qualitative metrics (satisfaction, well-being, cooperation) and quantitative ones (productivity, efficiency, quality) offers a valid framework for operationalizing the individual performance evaluation of telework, harmonizing the measurement of concrete deliverables with behavioral and psychosocial aspects intrinsic to work at a distance.

2.3 INDIVIDUAL PERFORMANCE EVALUATION INDICATORS IN TELEWORK

The content analysis of the 14 selected articles allowed the identification of various performance indicators that can be used to evaluate telework in the public administration.

Organizational performance evaluation indicators and the distinction of individual ones have been the object of study for years; for example, Vos and Voordt (2002) presented qualitative performance indicators, such as satisfaction and well-being, and quantitative ones, geared toward productivity. McCloskey (2003), in turn, addressed indicators such as productivity, work quality, technical skill, commitment, loyalty, cooperation, and integration with the team.

The authors Caraiani; Lungu; Dascalu; Stoian (2023) argue that individual performance indicators must be quantitative and qualitative, of which we may highlight: productivity (number of tasks completed in a given period of time); work quality (error rate, amount of rework, and accuracy in deliverables); technical skills (technical knowledge, mastery of tools and systems); behavioral skills (communication, teamwork, leadership, conflict-resolution capacity); alignment with objectives (achievement of individual and

collective goals, contribution to the results of the team and the organization); level of customer satisfaction (satisfaction surveys and service evaluations); professional development (participation in training, the pursuit of new knowledge and skills); and engagement and motivation (participation in projects and proactivity). Performance evaluation should focus on factors such as satisfaction, self-leadership, and the teleworker's autonomy (Müller, 2019). Luring (2025), in turn, points to other performance indicators by means of well-being, such as job satisfaction; satisfaction with time optimization; satisfaction with fewer commutes; and free-time management. Radonić (2021) focuses on indices of *output*, deliverables and goals achieved, and on the perception of well-being and fulfillment in the telework context. The study by McPhail (2023) highlights that traditional metrics, such as hours worked, do not apply to flexible models such as telework, and suggests indices of productivity (quantity of deliverables and completed projects); quality of deliverables (margin of errors and revisions); collaboration (engagement with the team and organization); innovation capacity (ideas and projects implemented); and well-being (work-life balance). Meanwhile, the study led by Claire Dupont warns of the challenges of organizations measuring only the performance immersed in productivity, which may lead the worker to an overload of activities, possibly triggering occupational illnesses, such as Burnout Syndrome.

The plurality of performance indicators identified in the literature demands legislation capable of operationalizing them in a fair and effective manner. In the context of the Brazilian public administration, this need materializes in a compilation of legal regulation that redefines the evaluation parameters under a results-oriented logic. Instruments such as Decree No. 11.072/2022 and the Normative Instructions of the MGI (especially Joint IN No. 24/2023) establish an explicit link between telework and evaluation systems based on goals and measurable indicators, reflecting the premise that performance must be gauged by deliverables and not by in-person presence. However, the effective application of the indicators—from productivity and quality to well-being and behavioral competencies—runs into the challenges of the practical translation of these legal guidelines, requiring of public managers a capacity for adaptation to the specificities of telework.

Considering the complexity of the identified indicators, it becomes crucial to analyze the legal framework that regulates them in the Brazilian public administration, the subject of the next section.

2.4 LEGISLATION ON TELEWORK IN THE BRAZILIAN PUBLIC ADMINISTRATION

The search for legislation and norms related to telework was carried out on the website of the Ministry of Management and Innovation in Public Services (MGI – *Ministério da Gestão*

e da Inovação em Serviços Públicos), in May 2025. The laws, decrees, and norms directly related to telework were selected, forming a compilation.

The regulation of telework in the Brazilian public sphere is a relatively recent process, intensified by technological advances and, above all, by the need for adaptation imposed by the COVID-19 pandemic. Unlike the private sector, where telework was included in the Consolidation of Labor Laws (CLT – *Consolidação das Leis do Trabalho*) by the Labor Reform of 2017 through Law No. 13.467/2017, the federal public service, governed by the Single Legal Regime (*Regime Jurídico Único*), Law No. 8.112/90, required the creation of specific norms for its implementation (Teixeira, Bacinello, 2024; Pereira, Rocha, 2025; Serpa, Guerra, Gonçalves, 2025). This item presents the legislative panorama that governs telework in the federal public administration, highlighting the points relevant to performance evaluation.

Before the specific norms for the federal public service, the discussion on telework in the federal public administration was permeated by debates about its compatibility with administrative principles, such as in-person presence and control. The absence of a legal framework generated legal uncertainty and disparity of rules among the different bodies and entities (Novelli, Ribeiro, 2025; Pereira, Rocha, 2025).

Law No. 13.467/2017, regarding the Labor Reform, inserted telework into Art. 75-B of the CLT; although it does not apply directly to statutory public servants, it served as a catalyst for the debate and for the perception of the need for regulation in the public sector as well. The principles of performance measurement by tasks and goals, present in the CLT, influenced the approach subsequently adopted for the public service (Serpa, Guerra, Gonçalves, 2025).

Normative Instruction (IN) No. 65, of July 30, 2020, of the Secretariat of People Management of the Special Secretariat for Debureaucratization, Management, and Digital Government of the Ministry of Economy (SGP/SEDGG/ME), represented a significant milestone for telework within the scope of the Civil Personnel System of the Federal Public Administration (SIPEC). Published in response to the demand imposed by the pandemic, this IN established the general guidelines and procedures for the implementation of telework, with a focus on the transition phase to the "new normal." Articles 5 and 6 highlight telework through a Work Plan with measurable goals and deadlines, and performance indicators. Articles 8 and 9 provide for monitoring focused on the delivery of goals and results, increased performance, and not on attendance or workday. And Article 13 provides for the exclusion of the participant from the PGD in the case of non-fulfillment of goals (Pantoja, Santos, and Marciano, 2025).

Decree No. 11.072/2022 [established the] PGD (Performance and Management Program – *Programa de Gestão e Desempenho*) [[nota: PGD mantido como sigla, com expansão e tradução, conforme regra 5]] within the scope of the direct, autarchic, and foundational Federal Public Administration (APF). It regulates the way in which federal public servants may carry out their activities, with a focus on results, and establishes rules for telework and other modalities of Management Program (GD). Considering performance evaluation, we may highlight some articles, such as Art. 3: expressly links telework to the PGD; Art. 4: PGDs must establish goals with indicators for measurement; Art. 5: allows higher performance goals for teleworkers; Art. 10: the PGD must contemplate modalities, goals, indicators, monitoring, and evaluation criteria; Art. 12: establishes monitoring and evaluation by a computerized system; and Art. 13: where the non-fulfillment of goals may lead to removal from the program (Teixeira, Bacinello, 2024).

Joint Normative Instruction SEGES-SGPRT/MGI No. 24, of July 28, 2023, establishes guidelines to be observed by the bodies and entities that are part of SIPEC and of the System of Institutional Organization and Innovation of the Federal Government (SIORG), regarding the implementation and execution of the PGD, with a focus on results, planning, and efficiency (Art. 1 and Sole Paragraph). This IN presents the modalities of the PGD (Arts. 7, 9, and 10): in-person (full workday at the headquarters or as defined by the administration); partial telework (part of the workday at a location chosen by the participant, part in person at the organization); and full telework (workday 100% at a location of the participant's choice). It also brings the possibility of the public servant performing full telework abroad (Art. 12) and allows bodies to lend equipment to public servants in full telework (Art. 16). Regarding evaluation, the IN establishes a five-phase cycle: preparation of the unit's delivery plan; agreement on the individual work plan; execution and monitoring; evaluation of the participant's work plan; and evaluation of the unit's delivery plan (Arts. 17 to 22). The individual evaluation is based on the fulfillment of the work plan, on the criteria predefined in the plan, and on the external factors that may impact the execution of the activities (Art. 21), all recorded in monthly reports (Art. 20) (Serpa, Guerra, Gonçalves, 2025; Santos and Jerônimo, 2025).

Joint Normative Instruction SGP-SRT-SEGES/MGI No. 52, of December 21, 2023, establishes guidelines regarding the rules of people management within the scope of the PGD, complementing IN 24/2023. It regulates procedures regarding occupational allowances (Art. 8), night-shift allowance (Art. 9), transportation assistance (Art. 10), occupational health and safety (Arts. 13 to 16), and Digital Offices (Art. 20). With respect to evaluation, the PGD work plan subsidizes all of the public servant's performance-management processes.

Performance is evaluated frequently and, when insufficient, may lead to the public servant's removal from the program (Arts. 3 to 6) (Ribeiro, Araújo, 2025; Vilarinho et al., 2023).

These laws, INs, and Decrees are the basis for telework in the APF (MGI, 2025) and, despite the advances, the legislation still presents challenges for the full operationalization of performance evaluation in telework. Many of the terms, such as applicable indicators or the form of monitoring, still demand practical detailing on the part of the bodies and entities, leaving room for different interpretations and measurement methodologies. The effectiveness of the evaluation will depend on the capacity of managers to translate these legal guidelines into performance-management practices that are fair, transparent, and aligned with organizational objectives (Pantoja, Santos, and Marciano, 2025).

The theoretical path undertaken in the preceding sections allowed the delineation of a structured set of analytical categories that will guide the methodological choices and procedures of this investigation. Based on the systematization proposed by Vos and Voordt (2002) and McCloskey (2003), and deepened by the contributions of Caraianni et al. (2023), Müller (2019), Radonić (2021), and McPhail et al. (2023), the individual performance indicators in telework were organized into two complementary axes: the quantitative, which encompasses productivity, quality of deliverables, fulfillment of goals, and conformity rates; and the qualitative, which incorporates well-being, satisfaction, work-life balance, engagement, and behavioral competencies such as virtual communication, proactivity, and self-management.

Furthermore, the examination of the Brazilian normative framework, embodied in Decree No. 11.072/2022 and in Normative Instructions No. 65/2020 and Joint SEGES-SGPRT/MGI No. 24/2023, evidenced the limits and institutional requirements that condition the operationalization of these indicators in the federal public administration. It is this conceptual and normative mapping that grounds and delimits the methodological strategy adopted in this study: the Systematic Literature Review by the ProKnow-C method, applied to the Science Direct, Scopus, and Web of Science databases, with descriptors aligned with the identified theoretical categories, and complemented by the documentary bibliographic research of the legislation, thus seeking to answer systematically the central question that motivated this investigation (Pantoja, Santos, and Marciano, 2025; Serpa, Guerra, Gonçalves, 2025).

3 METHODOLOGY

The choice of an adequate and objective methodology contributes to the validation and reliability of the data used, protects the study from the researcher's subjectivities and

beliefs, ensures the authenticity of the results, allows their reproduction in an assertive and standardized manner, and contributes to the construction of scientific knowledge (Marconi; Lakatos, 2022).

The research has a qualitative approach, of an applied nature, with descriptive objectives and the procedures of a Systematic Literature Review (SLR), by the Knowledge Development Process – Constructivist (ProKnow-C) method and Documentary Bibliographic Research. Qualitative research constitutes a methodological approach oriented toward the understanding and interpretation of the meanings attributed by individuals or groups to social or human phenomena (Creswell; Creswell, 2022).

The study is characterized as an SLR by means of the ProKnow-C method, a systematic process for selecting a bibliographic portfolio. It was developed to assist researchers in identifying and selecting the most relevant and representative articles on a given research topic, ensuring rigor and scientificity in the literature-review process. It allows for identifying, evaluating, and synthesizing the available evidence on a given research topic in an explicit and replicable manner, minimizing biases and ensuring the comprehensiveness and quality of the data collected (Nuernberg; Ensslin; Cardoso; Valmorbida, 2016). The main objective was to map and analyze the performance indicators for the evaluation of telework in the Brazilian public administration, as well as to seek to relate the legal framework that regulates this work modality.

3.1 SEARCH PERIOD AND DATABASES

The search for publications took place in the period from February to April 2025, without restriction of publication year, considering that the topic presents studies from the 1970s onward, evolving up to the present. The databases consulted included Science Direct, Elsevier's online platform that offers access to peer-reviewed scientific articles in various areas, such as health sciences, exact sciences, social sciences, and engineering; Scopus, one of the largest databases of abstracts and citations of peer-reviewed scientific literature; and Web of Science, a multidisciplinary platform that indexes high-impact journals.

3.2 SEARCH STRATEGY: DESCRIPTORS AND BOOLEAN OPERATORS

The search strategy was built from the combination of descriptors (keywords) and the Boolean operators AND and OR related to the research topic, with the objective of extracting relevant studies. The keywords "teletrabalho," "trabalho híbrido," "avaliação de desempenho," and "indicadores" were used, in Portuguese. In English: "*telework*" OR "*telecommuting*" AND "*hybrid work*" AND "*performance evaluation*" AND "*indicators*".

The searches in the databases were carried out in the title, abstract, and keyword fields of the publications, with filters by thematic area (Business, Management, and Accounting; Economics, Econometrics, and Finance; Decision Sciences and Multidisciplinary), Document Type (Article and Conference Article), English language, and fully open access.

The bibliographic search for publications resulted in 217 articles: 30 in Science Direct, 57 in Scopus, and 130 in Web of Science. The articles were exported and organized on the EndNote platform to form the library and organize the references. With the formation of the bibliography related to the research, the bibliometric analysis took place. In it, duplicate publications were excluded, and a survey of the articles with the highest number of citations was conducted, as well as of the most prominent authors.

3.3 INCLUSION AND EXCLUSION CRITERIA

To ensure the relevance and quality of the studies to be analyzed, rigorous inclusion and exclusion criteria were established.

Table 1

INCLUSION AND EXCLUSION CRITERIA

Inclusion	Exclusion
Complete scientific articles.	Non-systematic review articles, editorials, news, <i>press releases</i> , book chapters, dissertations, and theses.
Publications that address telework and performance evaluation	Publications that do not directly address performance evaluation or indicators
Studies that propose or analyze performance indicators for telework	Studies that do not present a clear methodology or consistent results
Articles and works available in full in the selected databases	Limited-access articles, with only the abstract available
Highest number of citations	Lowest number of citations

Source: Prepared by the authors (2026).

The following stage was the reading of the titles and abstracts of the non-duplicate articles. Those that did not meet the inclusion criteria or that fit the exclusion criteria were discarded. In this phase, a more in-depth evaluation of the pre-selected articles was carried out to confirm adherence to the inclusion and exclusion criteria. Articles that did not prove relevant after the full reading were excluded.

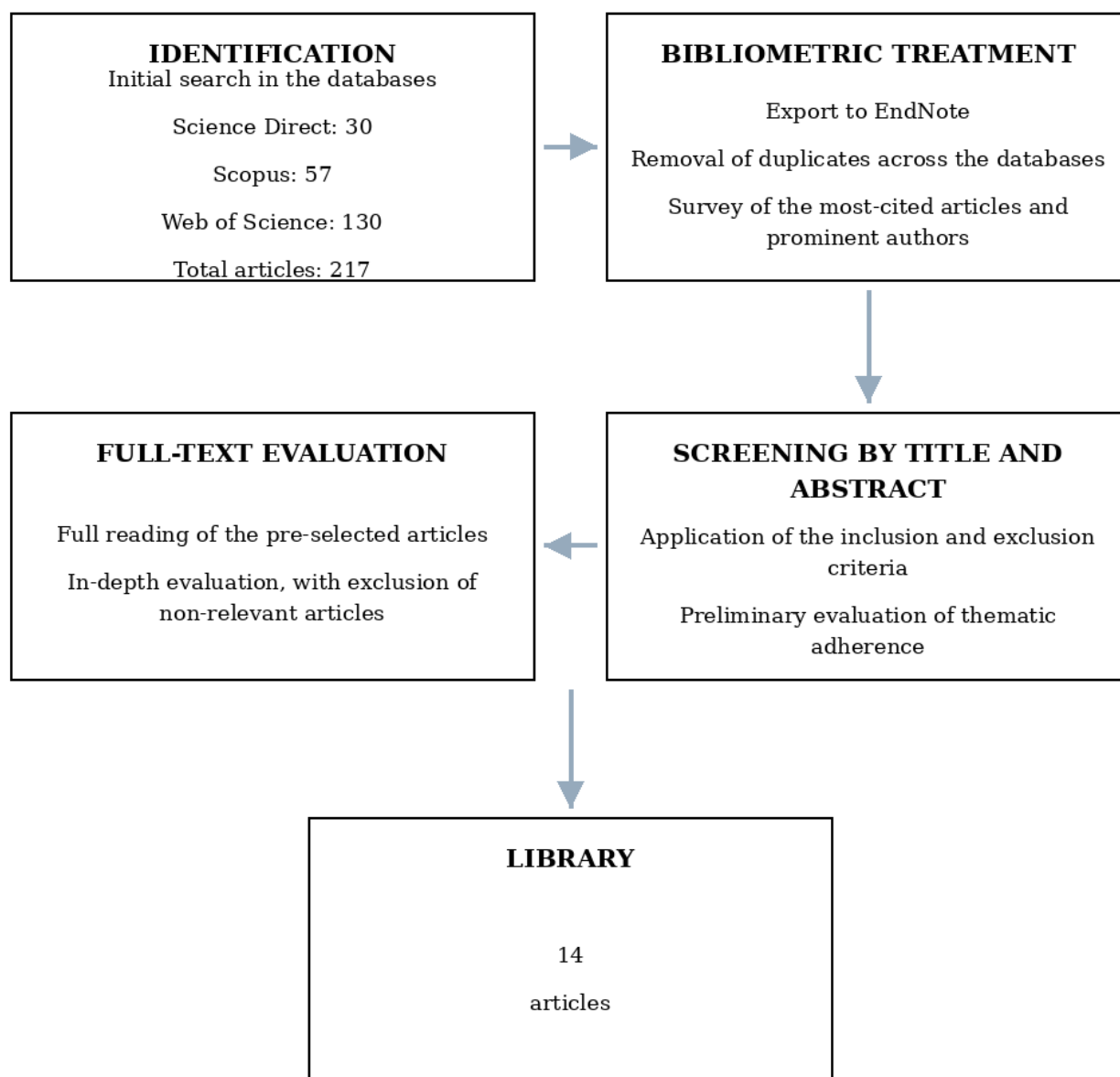
The portfolio was formed with 02 in Science Direct, 11 in Scopus, and 01 in Web of Science, composing the Library with 14 articles, as per the Table below:

Table 2
SYSTEMATIC LITERATURE REVIEW

Authors	Year	Article title	Journal
Aguinis, H.	2021	Talent management challenges during COVID-19 and beyond: Performance management to the rescue	BRQ Business Research Quarterly
Baumann, H. M.	2023	Human capital and legal perspectives on remote work: Recommendations for organizations	Management Research Review
Behrens, K.	2024	Working from home: Too much of a good thing?	Regional Science and Urban Economics
Bloom, N., Han, R., & Liang, J.	2024	Hybrid working from home improves retention without damaging performance	Nature
Caraiani, C., Lungu, C. I., Dascalu, C., & Stoian, C. A.	2023	The impact of telework on organisational performance, behaviour, and culture: Evidence from business services industry based on employees' perceptions	Economic Research-Ekonomska Istraživanja
Dupont, C., Giuliano, R., & Godfroid, C.	2023	Teleworking, task sharing, and work-life balance: A gender issue? Theoretical approach	Journal of Economics & Management
Kraus, S., Ferraris, M. A., & Bertello, A.	2023	The future of work: How innovation and digitalization re-shape the workplace	Journal of Innovation & Knowledge
Kuruzovich, J.	2021	Telecommuting and job outcomes: A moderated mediation model of system use, software quality, and social exchange	Information and Management
McCloskey, D. W.	2003	Does 'out of sight' mean 'out of mind'? An empirical investigation of the career advancement prospects of telecommuters	Information Resources Management Journal
McPhail, R., Chan, X. W., May, R., & Wilkinson, A.	2023	Post-COVID remote working and its impact on people, productivity, and the planet: An exploratory scoping review	International Journal of Human Resource Management
Müller, T.	2019	Self-leadership in the context of part-time teleworking	Journal of Organizational Behavior
Radonić, M.	2021	The impact of hybrid workplace models on intangible assets: The case of an emerging country	Amfiteatru Economic
Soga, L. R.	n.d.	Unmasking the other face of flexible working practices: A systematic literature review	Journal of Business Research
Vos, P., & Voordt, T.	2002	Tomorrow's offices through today's eyes: Effects of innovation in the working environment	Journal of Corporate Real Estate

Source: Prepared by the authors (2026).

The systematic literature review (SLR) process follows a rigorous methodological protocol to ensure the quality and replicability of the research. The following flowchart presents the stages carried out in the SLR on individual performance evaluation indicators in telework.

Table 3**ARTICLE SELECTION PROCESS**

Source: Prepared by the authors (2026).

4 RESULTS AND DISCUSSION

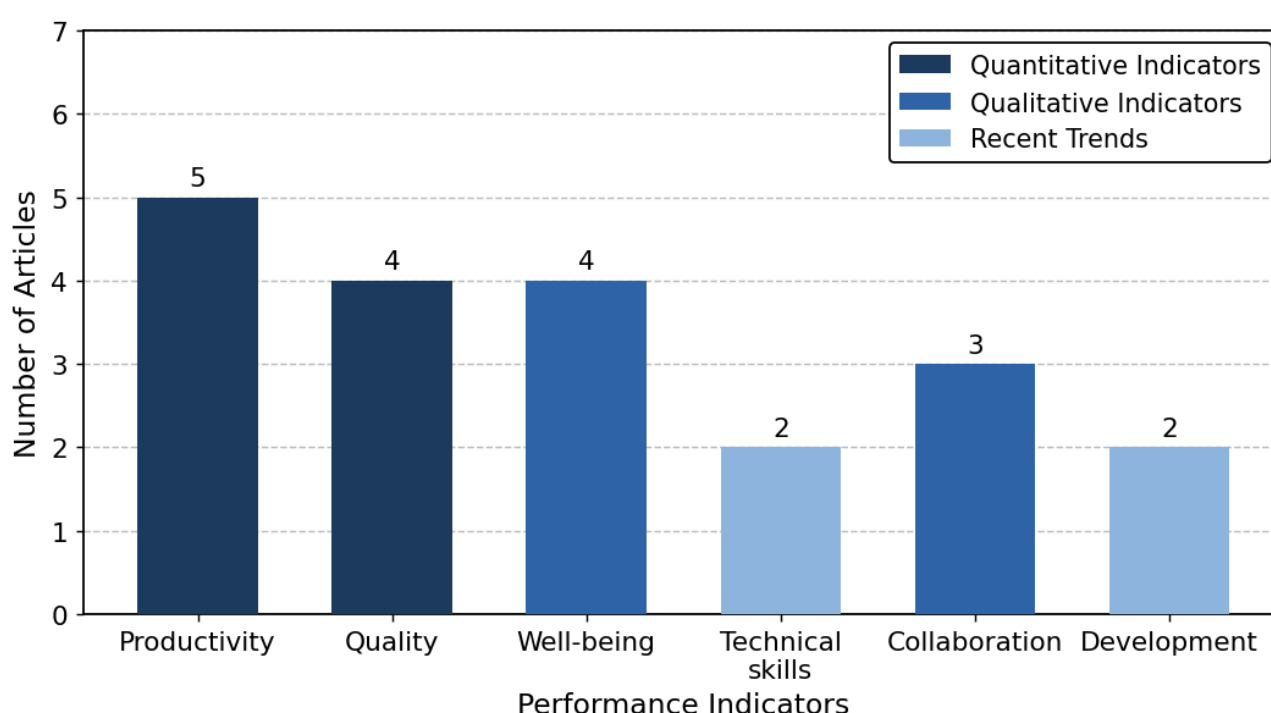
This section presents the results of the systematic literature review conducted, focusing on the identification and characterization of the performance indicators proposed and used for the evaluation of telework in the public administration.

The selected studies were published predominantly from 2000 onward, with a peak of publications in the years 2020 and 2021, reflecting the impact of the COVID-19 pandemic and the search to understand, regulate, and evaluate telework. The database with the highest number of relevant contributions was Scopus. As for the methodology of the studies, a predominance of mixed-nature research (qualitative and quantitative), by means of empirical studies, was observed.

The systematic review carried out demonstrates that performance evaluation in telework in the Brazilian public administration configures itself as a multifaceted challenge, demanding a balance between organizational efficiency and the public servant's well-being. The results presented in the graph below demonstrate a dichotomy between the theoretical propositions of the academic literature and the pragmatic approach adopted by Brazilian legislation, with significant implications for public management.

Figure 1

DISTRIBUTION OF PERFORMANCE INDICATORS IN TELEWORK BY NUMBER OF ARTICLES



Source: Prepared by the authors (2026).

The graph presents the frequency of each performance indicator identified in the portfolio articles. The dark-blue bars represent quantitative indicators (productivity and quality); the medium-blue bars represent qualitative indicators (well-being and collaboration); and the light-blue bars represent recent indicators (technical skills and development). The values indicate the number of articles that mention each indicator.

Figure 1 evidences the distribution of the performance indicators in telework identified in the literature, revealing the predominance of quantitative metrics, especially productivity (5 occurrences) and quality (4 occurrences), in line with the organizations' initial emphasis on maintaining and expanding deliverables in the remote context (Vos; Voordt, 2002; McCloskey, 2003; Caraianni et al., 2023; Müller, 2019; Radonić, 2021; McPhail, 2023). In

parallel, the presence of qualitative indicators is observed, such as well-being (4 occurrences) and collaboration (3 occurrences), which reflect a progressive broadening of the understanding of performance beyond strictly productive measurement, incorporating behavioral and relational dimensions, as advocated by recent multidimensional approaches (Caraiani et al., 2023; Müller, 2019; McPhail et al., 2023).

Furthermore, the indicators classified as recent trends—technical skills and development (both with 2 occurrences)—indicate an emerging research agenda geared toward continuous training and adaptability in telework, reinforcing the need for more comprehensive evaluation models aligned with the complexity of telework. Such a configuration corroborates the tension identified between the predominantly quantitative focus adopted by Brazilian legislation and the holistic perspective proposed by the international literature, evidencing the need for integration among efficiency, quality, and well-being in the evaluation of performance in the public sector.

It was observed that most of the studies focus on productivity indicators (Vos, Voordt, 2002; McCloskey, 2003; Caraiani et al., 2023; Müller, 2019; Radonić, 2021; McPhail, 2023), which is understandable given the organizations' initial concern with maintaining or increasing deliverables with the transition to telework, whether private or public. However, there is a growing valorization of quality indicators and, more recently, of indicators of worker well-being and satisfaction. This suggests an evolution of the understanding that performance in telework is not limited to the quantity produced, but also to the sustainability, quality, and impact on the public servant's well-being.

Previous studies point to multidimensional indicators, encompassing productivity and quality (deliverables, error rates, conformity); behavioral competencies (virtual communication, self-management, proactivity); and well-being and engagement (work-life balance, satisfaction, mental health) (Caraiani et al., 2023; Müller, 2019; McPhail et al., 2023).

This holistic approach contrasts with the Brazilian normative focus on the PGD. IN 65/2020, Decree 11.072/2022, and IN 24/2023 prioritize quantifiable goals, linking telework to individualized work plans with *output* indicators (Art. 4, Decree 11.072/2022). Although aligned with the principles of efficiency and *accountability* of the public service (Bresser-Pereira, 1998), this orientation presents gaps in the underdimensioning of subjective aspects, such as well-being and behavioral skills not formalized as evaluative dimensions in the legislation (Art. 21, IN 24/2023). The possibility of an increase in work, stimulated by higher goals for teleworkers, and removal due to failure (Arts. 5 and 13, Decree 11.072/2022) may foster overload, forming an antagonistic point in relation to well-being.

While the legislation requires objective goals (Art. 10, IN 24/2023), public bodies lack validated methodologies to gauge socio-emotional competencies or well-being (Kraus et al., 2023); perhaps the use of tools such as climate surveys, common in the private sector (Aguinis, 2021), could be used in the Brazilian public administration. Another challenge is the asymmetry in managerial training: public managers face difficulties in evaluating performance without in-person indicators, requiring training in remote leadership and continuous feedback (Müller, 2019). The disparity in technological infrastructure may also be a factor of difficulty. IN 52/2023 provides for the lending of equipment (Art. 16), but does not establish how, and does not mention the regional inequalities of connectivity, which may be reflected in the equity of the evaluation (Radonić, 2021). Combining quantitative and qualitative indicators, allied with ICTs, may be the solution to optimize the individual performance evaluation, as McPhail et al. (2023) propose.

The Brazilian public administration finds itself in a stage of transition, where the legislation provides the legal basis, but the literature points to the need for the humanization of the processes. The success of telework as a public-management tool will depend on the capacity of the bodies to transcend legal compliance, adopting models that balance tangible results and organizational health. The sustainability of remote work requires that performance indicators be vectors of efficiency and quality of life (Vilarinho et al., 2021).

The analysis of the individual performance indicators in telework, confronted with the Brazilian legal framework for the federal public administration, reveals a significant, yet complex, evolution in the way of measuring remote work. Evaluation in this context requires a multidimensional and balanced approach, overcoming traditional models based on physical presence or hours worked, as warned by McPhail (2023).

The reviewed studies (Vos, Voordt, 2002; McCloskey, 2003; Caraiani et al., 2023; Müller, 2019; Radonić, 2021; McPhail, 2023) converge on the need for hybrid indicators (quantitative and qualitative), highlighting: productivity and *output*, measured by completed tasks, delivered projects, and goals achieved (Caraiani et al., 2023; McPhail, 2023; Radonić, 2021), aligning perfectly with the focus on results and deliverables established by IN 65/2020, Decree 11.072/2022, and IN 24/2023 (PGD). Work quality, evaluated by the error rate, the need for rework, and accuracy (Caraiani et al., 2023; McPhail, 2023), complements the mere counting of tasks and reinforces the efficiency sought by the PGD. Technical and behavioral skills, such as technical knowledge, communication, collaboration, proactivity, and conflict resolution (Caraiani et al., 2023; McCloskey, 2003), are essential for the autonomy and self-leadership required in telework (Müller, 2019), being indirectly contemplated in the evaluation of the fulfillment of the Individual Work Plan (IN 24/2023). Well-being and satisfaction—

factors such as work-life balance, satisfaction with time optimization, and fulfillment (Müller, 2019; Radonić, 2021; McPhail, 2023)—emerge as important indicators in the prevention of overload and burnout (Dupont et al., 2025). Engagement—contributing to organizational objectives, participation in projects, and professional development (Caraiani et al., 2023)—is present in the telework evaluation cycle in the PGD, promoted by IN 24/2023, with the agreement and evaluation of individual and unit plans seeking to promote this alignment.

Brazilian legislation (IN 65/2020, Decree 11.072/2022, IN 24/2023, IN 52/2023) established a solid legal foundation oriented toward results, especially through the PGD. The focus on measurable goals, individualized work plans, and evaluation by deliverables reflects the influence of the task-based approach of the CLT and responds to the need for evaluation in telework.

However, significant challenges persist, such as the risk of hyperfocus on productivity. The strong legal emphasis on the fulfillment of quantitative goals (with consequences such as removal from the PGD – Art. 13 of Decree 11.072/2022) may, if not balanced, lead to overload and exhaustion, as we saw earlier. The explicit integration of well-being as an evaluative dimension is a deficiency to be overcome.

The main findings of this research reveal a dual perspective. On the one hand, the academic literature points to the need for a performance evaluation of telework that transcends mere quantitative productivity, incorporating dimensions such as work quality, the fulfillment of goals, worker well-being and satisfaction, and even indicators of cost-effectiveness and organizational impact (Aguinis, 2021). On the other hand, Brazilian legislation on telework in the public administration establishes a more pragmatic approach, strongly oriented toward the fulfillment of objective goals and results, with the integration of telework into the PGD. Although essential for accountability and efficiency, this legal basis still presents gaps regarding the detailing of how the qualitative indicators and those related to well-being should be operationalized. The legislation imposes what must be measured—the results—but offers less direction on how to measure the totality of performance and its nuances.

The present systematic literature review, complemented by the analysis of Brazilian legislation, revealed a multidimensional panorama of the performance indicators for the evaluation of telework in the Brazilian public administration—a discussion that continues in the effort to integrate the findings, articulating the theoretical propositions with the normative requirements and the practical actions.

Brazilian legislation consolidated the regulation of telework in the federal public administration and demonstrated a preponderant focus on the measurement of quantitative

results and the fulfillment of objective goals. By linking telework to the PGD, the norm establishes the need for deliverables to be measurable, including with the possibility of goals higher than those of in-person work.

This partial convergence between academia and legislation suggests that, although theory recognizes the complexity of performance—including subjective and well-being aspects—legislative practice prioritizes the tangible and the measurable, probably for reasons of accountability and control. The challenge, therefore, lies in how public bodies can go beyond the legal minimum, incorporating qualitative and humanized indicators without compromising the objectivity and transparency required by the public sector.

5 CONCLUSION

This study had as its general objective to analyze the performance indicators for the evaluation of telework in the Brazilian public administration, based on a systematic review of the literature related to the pertinent legislation. To this end, it sought to identify and synthesize the indicators proposed in academia, to map the legal framework, and to discuss the gaps and challenges in the application of these metrics in the context of the Brazilian public administration.

The articulation between the findings of academia and the legal panorama reveals that the Brazilian public administration finds itself in a stage of maturation in the management of telework. There is an opportunity for public bodies to go beyond minimum compliance with the law, developing more robust evaluation systems that absorb the propositions of the literature on the importance of more comprehensive indicators.

Therefore, it is concluded that individual performance evaluation in telework in the Brazilian public administration demands a hybrid and balanced model, which incorporates both the objectivity of quantitative goals and the quality of deliverables (as required by the PGD) and the essential subjectivity of behavioral skills, collaboration, and, above all, the public servant's well-being. The success of this evaluation lies in the capacity to reconcile the pursuit of efficiency and results, enshrined in the legislation, with the protection of the teleworker's health and motivation, ensuring that telework is sustainable and productive in the long term.

The main contribution of this study consists in bringing together the knowledge on the individual performance indicators of telework, offering an integrated panorama of the theoretical and legal perspectives. This may serve as a valuable reference for public managers in the design and improvement of their own evaluation systems, as well as contribute to academic research on the subject.

Despite the efforts undertaken, this study has some limitations, which may be mitigated in future research, such as empirical studies that investigate the real application and effectiveness of telework performance indicators in public organizations. In this sense, it is suggested for future research that case studies be carried out in federal public administration bodies that have already implemented telework in a consolidated manner, seeking to analyze in practice which indicators are being used, how they are collected, and what the perception of managers and public servants is regarding their effectiveness. Additionally, research exploring the relationship between performance evaluation in telework and the mental health of public servants, as well as comparative studies with international experiences, may further enrich the studies.

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SUCCESSION JUSTICE AND STRUCTURAL INEQUALITIES: THE PROTECTION OF PERSONALITY RIGHTS IN THE CONTEXT OF INDIVIDUAL AUTONOMY AND ESTATE PLANNING UNDER DISCUSSION IN BILL N. 04/2025

JUSTIÇA SUCESSÓRIA E DESIGUALDADES ESTRUTURAIS: A PROTEÇÃO DOS DIREITOS DAS PERSONALIDADES NO CONTEXTO DA AUTONOMIA INDIVIDUAL E O PLANEJAMENTO SUCESSÓRIO EM DISCUSSÃO NO PL 04/2025

JUSTICIA SUCESORIA Y DESIGUALDADES ESTRUCTURALES: LA PROTECCIÓN DE LOS DERECHOS DE LA PERSONALIDAD EN EL CONTEXTO DE LA AUTONOMÍA INDIVIDUAL Y LA PLANIFICACIÓN SUCESORIA EN DISCUSIÓN EN EL PL 04/2025



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ABSTRACT

This article analyzes estate planning in light of personality rights theory and a gender perspective, considering the transformations proposed by Bill No. 4/2025, which aims to reform the Brazilian Civil Code. It argues that estate planning should be understood as an instrument of existential protection rather than merely patrimonial organization. The research adopts a qualitative, bibliographic, and documentary methodology, with a civil-constitutional and interdisciplinary critical approach. It examines the tension between private autonomy and the protection of vulnerable subjects, especially women in contexts of structural inequality. It concludes that expanding testamentary freedom may deepen social asymmetries if not interpreted through human dignity and gender-sensitive lenses.

Keywords: Estate Planning. Personality Rights. Gender. Intersectionality. Civil Code.

RESUMO

O presente artigo analisa o planejamento sucessório à luz da teoria dos direitos da personalidade e da perspectiva de gênero, considerando as transformações propostas pelo Projeto de Lei nº 4/2025, que visa reformar o Código Civil brasileiro. Parte-se da hipótese de que o planejamento sucessório deve ser compreendido como instrumento de tutela existencial, e não apenas como técnica de organização patrimonial. A pesquisa adota metodologia qualitativa, de natureza bibliográfica e documental, com abordagem civil-constitucional e crítica interdisciplinar. Examina-se a tensão entre a autonomia privada e a proteção de sujeitos vulneráveis, especialmente mulheres em contextos de desigualdade estrutural. Conclui-se que a ampliação da autonomia sucessória, se não interpretada à luz da dignidade da pessoa humana e da perspectiva de gênero, pode aprofundar assimetrias sociais.

Palavras-chave: Planejamento Sucessório. Direitos da Personalidade. Gênero. Interseccionalidade. Código Civil.

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RESUMEN

Este artículo analiza la planificación sucesoria a la luz de la teoría de los derechos de la personalidad y de la perspectiva de género, considerando las transformaciones propuestas por el Proyecto de Ley nº 4/2025, que busca reformar el Código Civil brasileño. Se parte de la hipótesis de que la planificación sucesoria debe comprenderse como instrumento de tutela existencial, y no meramente como técnica de organización patrimonial. La investigación adopta metodología cualitativa, de naturaleza bibliográfica y documental, con enfoque civil-constitucional e interdisciplinario crítico. Se examina la tensión entre la autonomía privada y la protección de sujetos vulnerables, especialmente mujeres en contextos de desigualdad estructural. Se concluye que la ampliación de la autonomía sucesoria, si no se interpreta a la luz de la dignidad de la persona humana y de la perspectiva de género, puede profundizar las asimetrías sociales.

Palabras clave: Planificación Sucesoria. Derechos de la Personalidad. Género. Interseccionalidad. Código Civil.

1 INTRODUCTION

The Law of Succession, traditionally structured under a patrimonialist perspective, has been undergoing significant transformation in the contemporary Brazilian legal scenario. Such a reconfiguration stems from the centrality assumed by the dignity of the human person as a foundation of the legal order, as well as from the progressive functionalization of civil-law institutes, which come to be interpreted in light of values such as solidarity, existential protection, and the fulfillment of the person.

In this context, succession ceases to be understood as a mere transfer of assets by reason of death, assuming the role of an extension of the individual's life project, allowing their choices, values, and affective bonds to project themselves beyond biological existence.

In this movement of evolution, personality rights gain prominence as a structuring axis of contemporary civil interpretation. Such rights, inherent to the human condition, come to radiate effects over the various branches of Private Law, including the succession domain. Thus, the understanding is consolidated that the legal order must ensure broad protection for the dignity of the person, not limiting itself to the traditional categories but reaching all existential manifestations that demand legal protection. This perspective broadens the reach of civil norms and reinforces the need for a systematic reading geared toward the promotion of the human person.

As a consequence, the classic dichotomy between patrimony and personality tends to be attenuated. Patrimony comes to be understood not only as a set of economically appraisable assets, but as an instrument for the realization of individual freedom and autonomy. In the succession domain, this understanding intensifies, since the destination of the assets reflects existential choices, personal values, and affective relationships built over the course of life. Thus, succession also assumes a symbolic and identity-related dimension, linking itself to the continuity of the individual's existential project.

In this scenario, estate planning emerges as an essential tool of legal organization and the realization of private autonomy. More than a mechanism geared toward economic efficiency or the reduction of tax burdens, it presents itself as an instrument for the prevention of conflicts, the protection of family interests, and the preservation of personal and business values. Through it, it becomes possible to structure, in a conscious and strategic manner, the transfer of patrimony, aligning it with the existential objectives of the owner of the assets.

The complexity of the topic intensifies in the face of the contemporary proposals for reform of Civil Law, which seek to adapt the succession system to social and technological transformations. These changes raise relevant debates regarding the expansion of private autonomy, the loosening of traditional rules, and the redefinition of the subjects protected by

the succession system. In this context, a critical analysis is required that considers not only economic and formal aspects, but also the social impacts and the need to protect subjects in a situation of vulnerability, especially in light of approaches that recognize the plurality of experiences and structural inequalities.

In view of this panorama, the present study aims to examine the relationship between personality rights and estate planning, investigating in what way contemporary legal instruments can contribute to the protection of identity, of affective bonds, and of the dignity of the human person. To this end, the work is structured in axes that address the evolution of the concept of patrimony under an existential perspective, the modern mechanisms of estate planning, the legislative transformations under way, the non-patrimonial dimension of succession, and the need for an application of the Law that is sensitive to social vulnerabilities.

In the end, it seeks to demonstrate that estate planning, when oriented by ethical and constitutional foundations, can promote a succession justice that goes beyond the merely patrimonial logic, reconciling autonomy, responsibility, and intergenerational solidarity.

2 ON PERSONALITY RIGHTS AND THEIR PATRIMONIAL PROJECTION – CONTEMPORARY ESTATE PLANNING

2.1 ON THE LEGAL STRUCTURE OF PERSONALITY RIGHTS

Personality rights constitute the hard core of the legal protection of the human being. Unlike patrimonial rights, which are disposable, subject to prescription, and alienable, personality rights are, as a rule, non-transmissible and non-waivable, and their exercise cannot suffer voluntary limitation (Art. 11 of the Civil Code). Carlos Alberto Bittar (2015) defines them as the rights inherent to the person and to their dignity, which accompany the individual from birth—or even before, from the perspective of the unborn child (*nascituro*)—until after their death.

Historically, classical doctrine limited itself to protecting isolated physical and moral aspects, such as life, physical integrity, honor, and image. However, social and technological evolution required an expansion of this list. The theory of personality rights came to be a foundation of the Republic (Art. 1, III).

Contemporary civil-law doctrine, influenced by the thought of Pietro Perlingieri (2002), defends the existence of a general clause for the protection of personality. This means that the legal order protects not only the rights typified in the law, but any manifestation of human dignity that requires shelter. According to Luiz Edson Fachin (2003), this clause operates as

a radiating principle that obliges the judge to interpret all civil norms—including those of succession—in such a way as to maximize the existential protection of the individual:

The protection of personality is not exhausted in specific legal types, it being necessary to recognize a general protection, founded on the dignity of the human person, apt to encompass situations not expressly foreseen (Fachin, 2004, p. 55).

In this sense, the rigid distinction between being (personality) and having (patrimony) begins to fade. Stefano Rodotà (2010) points out that, in contemporary society, patrimony often serves as support for the exercise of freedom. Without a minimum of material resources, the individual cannot fully exercise their personality rights. Therefore, the protection of personality projects itself onto the management of assets, especially at the moment of succession, where the destination of the patrimony reflects the existential choices of the *de cuius*.

The reinterpretation of patrimony under the existential lens is fundamental for estate planning. Patrimony is not an end in itself, but a means for the realization of the life project. Maria Celina Bodin de Moraes (2010) argues that human dignity possesses a relational and temporal dimension. The individual builds their identity through their relationships and through the way they organize their life and their resources.

When a person plans their succession, they are, in fact, giving continuity to their life project. They may wish to protect a child with a disability, ensure the maintenance of a family business that generates jobs and preserves the family's legacy, or even allocate resources to social causes that marked their trajectory. In these situations, patrimony assumes a clear social and existential function. Estate planning, therefore, is the legal tool that allows this projection of personality onto patrimony to be respected after death, within the limits of legality and solidarity.

2.2 ON ESTATE PLANNING AND ITS LEGAL INSTRUMENTS

Estate planning may be defined as the legal-strategic process that aims to organize the transfer of a person's patrimony after their death, seeking to minimize family conflicts, reduce the tax burden, and ensure the continuity of businesses or personal values. Rolf Madaleno (2021) emphasizes that planning is an act of prevention and of love, for it prevents heirs from facing slow and costly probate proceedings, which often destroy patrimony and affective bonds.

Estate planning performs multiple and complementary functions in the legal and patrimonial sphere. From the organizational perspective, it allows the prior definition of the

destination of the assets, clearly establishing who will receive each portion of the patrimony, which contributes to the prevention of conflicts among heirs. On the economic plane, it seeks tax efficiency, especially with regard to the incidence of the ITCMD (Tax on Causa Mortis Transmission and Donation) and the IRPF (Individual Income Tax) [[nota: siglas tributárias brasileiras mantidas, com tradução do termo por extenso entre parênteses, conforme regra 5]], besides making possible the reduction of procedural costs related to succession.

Such a perspective must always be envisioned in a broad sense, so that, among the possibilities, the most efficient choice is made—not only from the tax standpoint. As Fleischmann and Tremarin Junior (2019, p. 625) explain:

although it is an essential element of analysis, tax efficiency cannot be considered one of the main objectives of estate planning, which does not mean a necessary saving of taxes. There will be situations in which, from the tax standpoint, estate planning will be inadvisable, but advisable from the standpoint of the perpetuity of the patrimony [...]. In this sense, before opting for the holding system, it may be important to analyze the traditional forms of planning and compare them with the use of the holding, for what leads to the choice of one form or another are the objectives of the plan.

In the preservative dimension, in turn, it reveals itself as an essential instrument for the continuity of family businesses, through the adoption of mechanisms such as shareholders' agreements and governance structures that ensure the stability of the business activity. Flávio Tartuce (2023, p. 1,945) teaches that:

Estate planning represents a technique of legal conformation of family and patrimonial relationships, functioning as a preventive mechanism of conflicts and an instrument of stability in private relationships.

It also presents an existential function, by making viable the inclusion of provisions of a non-patrimonial nature, such as the recognition of children, directives on funeral rites, and guidance regarding the management of digital assets, evidencing the interface between patrimony and personality rights.

Private autonomy is the engine of estate planning. It confers on the individual the power to create legal norms to regulate their own interests. In the succession domain, this autonomy manifests itself mainly in the freedom to make a will. However, in the current Brazilian system, this freedom is limited by the forced portion (*legítima*)—the reservation of 50% of the patrimony for the forced heirs (descendants, ascendants, and spouse), in accordance with Art. 1,845 of the Civil Code.

Judith Martins-Costa (2018) stresses that private autonomy is not an absolute right, but rather a functionalized one. It must serve lawful ends and respect the principles of

objective good faith and social function. The clash between the sovereign will of the author of the inheritance and the imperative protection of the family is the great theme of modern Succession Law. Bill No. 4/2025 proposes to shift this balance significantly in favor of individual autonomy, which requires a critical analysis of the social consequences of this choice.

The sophistication of contemporary estate planning manifests itself in the diversity of available legal instruments, frequently used in combination to meet the peculiarities of each family and patrimonial nucleus. Among these mechanisms, the will remains the most traditional instrument, being able to assume the public, sealed, or private modalities. Its main advantage lies in the possibility of revocation at any time, besides allowing the inclusion of provisions of an existential nature. However, it finds a limitation in the need to respect the forced portion (*legítima*), bearing only on the disposable part of the inheritance:

Often the will has the objective of reflecting the transactions entered into for the purpose of estate planning, ratifying them; for example, a father who donates an asset to one of his children—respecting what he could donate, in relation to the patrimony of which, at the moment of the liberality, he was the holder—and, in the expression of last will, exempts them from collation (*colação*). Indeed, the exemption from collation may take place in the will or by express reference in the title of the liberality (Vieira, 2020, p. 41).

Modern estate planning breaks with the view that the will is a mere inventory of assets. It comes to be a vehicle for the expression of personality. Provisions of a non-patrimonial character (Art. 1,857, § 2 of the Civil Code) gain prominence. The testator may use the instrument to: recognize a socio-affective child; appoint a guardian for minor children; establish directives on the destination of their mortal remains (cremation, organ donation); record confessions, requests for forgiveness, or bequeath moral and ethical values to the family.

These clauses are irrevocable even if the patrimonial will is annulled or revoked, demonstrating the supremacy of the existential aspect over the material one. Maria Celina Bodin de Moraes (2010) holds that these provisions are the conclusive proof that private autonomy projects itself beyond biological life, allowing the individual's voice to continue echoing in their affective community.

Another widely used instrument consists of donations with reservation of usufruct, which make possible the early transfer of the bare ownership to the heirs, preserving for the donor the right of use and enjoyment of the asset, such as the receipt of income or the permanence in the property until their death. It is an effective mechanism for avoiding the

incidence of probate on such assets, contributing to greater speed and economy in the succession process.

In the business sphere, family holding companies stand out, structured by means of the incorporation of a legal entity intended for the concentration of the family patrimony. In this model, succession occurs through the transfer of corporate quotas, which allows greater control over the administration of the assets, besides the insertion of restrictive clauses, such as non-seizability (*impenhorabilidade*) and incommunicability (*incomunicabilidade*), reinforcing patrimonial protection and family governance.

In addition, instruments of an insurance and pension nature also play a relevant role in estate planning. Private pension plans, especially in the VGBL and PGBL modalities, present the advantage of, as a rule, not being subject to probate, making possible the free designation of beneficiaries:

In PGBL plans (and provided that the participant is also a contributor to or beneficiary of Social Security), the contributions paid to the plan may be deducted from the calculation basis of Income Tax, by up to 12% of the annual gross income, in the option of the complete annual adjustment declaration (Girardi; Moreira, 2019, p. 634).

The case law of the Superior Court of Justice (Superior Tribunal de Justiça – STJ)¹ has been consolidated in the sense that such amounts, except in cases of fraud, do not form part of the calculation basis of the forced portion. In a similar manner, life insurance, by possessing an indemnity nature—as Article 794 of the Civil Code provides—is not characterized as inheritance, being paid directly to the beneficiaries, quickly and, in many cases, without the incidence of ITCMD.

Finally, prenuptial agreements (*pactos antenupciais*) and cohabitation contracts (*contratos de convivência*) constitute essential instruments in patrimonial and succession organization, for they allow the prior definition of the property regime applicable to the relationship, directly influencing the rights of the marital share (*meação*) and succession of the spouse or partner. In this way, it is evidenced that contemporary estate planning is not limited to a single instrument, but is built from an integrated legal architecture, capable of articulating economic efficiency, patrimonial protection, and the realization of existential interests.

Succession self-determination is the right of each person to be the architect of their own legal end. This includes the freedom not to leave an inheritance, to privilege philanthropic causes, or to establish conditions for the heirs to receive the assets (performance or conduct clauses, provided they do not violate human dignity).

Existential autonomy allows estate planning to be an instrument of emancipation. For example, an LGBTQIA+ person may use planning to ensure that their partner receives the protection that the biological family, at times hostile, would deny. In this case, estate planning acts as a protective shield for the identity and the affective bonds built during life, reaffirming that the family is a concept founded on affection and not only on blood.

Despite the broad freedom, the disposition of personality finds limits in ethics and public order (Gonçalves, 2023, p. 192). It is not admitted, for example, that a testator impose conditions that violate the religious, matrimonial, or professional freedom of their heirs. Such clauses are considered null for violating fundamental rights of the successors.

The challenge of the contemporary jurist is to balance the will of the deceased with the freedom of the living. Estate planning cannot be an instrument of tyrannical posthumous control, but rather a proposal of harmonious continuity. The ethics of solidarity must permeate all planning structures, ensuring that private autonomy does not become a vehicle of arbitrariness or unjustified exclusion.

3 ON THE REFORM OF THE CIVIL CODE: BILL No. 4/2025 AND THE RECONFIGURATION OF SUCCESSION

The processing of Bill No. 4/2025 in the Federal Senate, under the rapporteurship of Senator Rodrigo Pacheco, marks the beginning of a new era for Brazilian Civil Law. The proposal is the fruit of the work of a Commission of Jurists, presided over by Justice Luis Felipe Salomão (STJ), which sought to update the 2002 Code to reflect the transformations of Society 5.0. The Book of Succession is, without a doubt, one of those that suffered the most profound modifications, with the declared objective of simplifying the succession system and expanding individual freedom.

The foundations of the reform reside in the premise that the current model is excessively interventionist and bureaucratic. The commission argues that the Law must respect the will of the owner of the patrimony, allowing them to decide the destination of their assets with greater flexibility. In addition, the reform seeks to harmonize the Civil Code with the new forms of family and with the digital reality, themes that the 2002 legislator could not foresee in their totality.

The main guideline of Bill No. 4/2025 is the strengthening of private autonomy. The reform proposes the reduction of formal obstacles for the preparation of wills and, more importantly, the admission of new estate-planning instruments that were previously viewed with reservations or prohibited by the legal order.

One of the most significant advances is the regulation of Succession Pacts (Art. 426 of the current Civil Code, which prohibits the *pacta corvina*). Such an expression admits more than one meaning:

The expression succession pact is used, in a restricted sense, to designate the agreement or contract whose object is the succession of one or of both contracting parties. In a broad sense, however, the expression encompasses not only the agreements whose object is the succession of one of the contracting parties but also any and all contracts concerning the inheritance of a living person (Cruz, 1965, p. 94).

The bill proposes to make this prohibition of the *pacta corvina* more flexible, allowing the heirs and the author of the inheritance to enter into agreements during life regarding the future division, provided that certain ethical limits and the protection of vulnerable persons are respected. This brings unprecedented legal certainty for business families that wish to organize corporate governance and the succession of corporate quotas in an anticipated and consensual manner.

The most impactful and controversial change of Bill No. 4/2025 is the exclusion of the spouse and the partner from the list of forced heirs (Art. 1,845). In the current system, the spouse (and, by equivalence established by the STF in RE 878.694/MG, the partner) is guaranteed a portion of the inheritance, regardless of the testator's will, competing with descendants and ascendants.

The justification for this change is that the spouse already possesses protection through the marital share (*meação*) (depending on the chosen property regime). The commission of jurists holds that maintaining the spouse as a forced heir generates distortions, especially in marriages of short duration or where there has already been an effective patrimonial separation during life. The proposal allows the testator, should they have no descendants or ascendants, to dispose freely of 100% of their patrimony, being able to leave the partner with nothing in the succession, should they so wish.

In addition to the exclusion of the spouse, Bill No. 4/2025 proposes a redefinition of the calculation of the forced portion. The idea is to simplify the calculation basis and allow certain liberalities made during life not to be computed as an advance on the forced portion as rigidly as today.

The making of the forced portion more flexible aims to give more power to the author of the inheritance to privilege an heir who needs more care or who has contributed more to the formation of the patrimony. Francisco José Cahali (2019) observes that the forced portion, although it is an instrument of family solidarity, often stiffens planning and generates injustices in cases where the affective relationship between parents and children is nonexistent or

conflictual. The bill seeks a middle ground between total freedom and absolute family protection.

The reform also embraces modernity by including provisions on digital inheritance. The bill defines that digital assets (cryptocurrencies, airline miles, social-media profiles with economic value) form part of the hereditary estate. More than that, it establishes rules for access to private data, seeking to balance the successors' right to inheritance with the right to privacy and to the secrecy of the deceased's communications.

Digital inheritance is one of the most fertile fields for the study of personality rights in succession. What happens to our photos on Instagram, our conversations on WhatsApp, or our files in the cloud after death? The STJ, in REsp 1.660.168/RJ, began to tread this path by recognizing that digital assets possess legal relevance.

In this context, Carroll and Romano (2011) identify five types of digital assets that need to be considered after the death of a user: 1) devices and data, which include the deceased's electronic devices and the documents contained therein; 2) e-mails, which encompass received messages and the possibility of continued access to the account; 3) online accounts, services that require a username and password, containing text messages, photos, and/or videos; 4) online financial accounts linked to a bank or financial account; and 5) online businesses, such as virtual stores with the potential to generate revenue.

However, the great tension lies in the conflict between inheritance and privacy. While the heirs wish to access the memories of the deceased, the *de cuius* may have secrets that they did not wish to reveal. Existential estate planning allows the individual to appoint a digital curator or to use tools of the platforms themselves to define who may manage their digital legacy, ensuring that their memory is preserved in accordance with their will, protecting their honor and image *post mortem*.

The inclusion of digital assets in the Civil Code is, without a doubt, an indispensable legislative advance. As Facchini (2024) highlights, the current legal system is not capable of dealing with the new forms of patrimony that have emerged due to the digitalization of everyday life, especially when these assets possess economic relevance or symbolic value for the family members of the deceased.

The legislative proposal also relates to the protection of the personal data of the deceased, since Bill No. 4/2025 dialogues with the General Personal Data Protection Law (LGPD – Lei Geral de Proteção de Dados Pessoais, Law No. 13.709/2018) [[nota: sigla LGPD mantida, com tradução do termo por extenso, conforme regra 5]]. By granting the heirs the right to access or delete digital content, respecting privacy and personality rights even after death, the bill reinforces the protection of human dignity, as Matos (2024) argues.

However, as Lima (2023) points out, making access to digital assets more flexible may accidentally result in violations of privacy, especially if the deceased does not leave clear guidance. This question becomes particularly sensitive in the case of private messages, intimate media, and information shared with third parties that may be exposed without the consent of those involved.

Another delicate point concerns the applicability of the norms in the face of international platforms that operate under different legal regimes. The normative standardization proposed by Bill No. 4/2025 may come into conflict with the internal policies of these companies, which frequently refuse to allow access to inactive accounts without a court order, even when there is proof of death.

A further innovation is the genetic will (*testamento genético*), which allows the individual to dispose of the destination of their cryopreserved genetic material (eggs, sperm, embryos). This provision is fundamental for regulating *post mortem* succession in cases of assisted reproduction, avoiding ethical and legal conflicts over the filiation and succession rights of children conceived after the death of one of the parents.

Along the same lines of the innovations, the proposal of a new fideicommissum (*fideicomisso*) stands out, which bears a certain similarity to the Anglo-Saxon trust, in the sense of a true socioeconomic operation geared toward estate planning. In the words of Maria Helena Diniz (2022, p. 326):

A fideicommissum is the testamentary provision by which the testator transmits the inheritance or legacy to a fiduciary heir, with the charge of, upon their death or the fulfillment of a condition, transferring it to another beneficiary, called the fideicommissary.

Cláudia Stein Vieira (2020), in her Doctoral thesis defended at the Universidade de São Paulo, sets forth that our legal structure is not yet flexible enough to allow the patrimonial arrangements that are consonant with the current reality:

there is a relevant gap in the Brazilian system that is not directly filled by any institute currently in force. The Brazilian citizen lacks autonomy to benefit two persons, simultaneously or successively, in view of the compulsory conversion of the instituted fideicommissum into usufruct, if, at the time of the respective death, the fideicommissary is alive. Apart from this, there is no autonomy, in Brazil, to proceed with the various business, contractual, and succession arrangements made possible by the trust abroad (Vieira, 2020, p. 59).

The current doctrinal position turns toward the legitimacy of the constitution of the fideicommissum both in donation and in other contractual relationships, as Adriano Faria da Silva (2007, p. 163) teaches:

A significant impulse to this institute, for it could serve to regulate with greater certainty certain civil and mercantile legal transactions, still during the life of the institutor. In any case, even though not expressly foreseen in our legal order, there is no legal impediment to its institution by *inter vivos* acts, both in donations and in other contractual relationships. It seems perfectly viable to us to institute a fideicommissum in a contract of purchase and sale with an adjoined fideicommissary pact.

A relevant point of the proposal is the expansion of the versatility of the fideicommissum, which would come to serve multiple purposes, such as succession instruments, guarantee mechanisms, investment structures, and arrangements geared toward specific purposes, including for the protection of persons in a situation of vulnerability. This multifunctionality reinforces the potential of the institute as a central tool in contemporary patrimonial law.

The reformulation of the fideicommissum requires the clear definition of the duties and responsibilities of the fiduciary, who must act with high standards of diligence and loyalty, similar to the administrators of companies. The accountability for any losses arising from poor management or violation of fiduciary duties is an essential element for ensuring the trust and effectiveness of the institute.

4 ON THE PROTOCOL OF GENDER AND VULNERABILITY IN SUCCESSION LAW: ESTATE PLANNING AS AN INSTRUMENT OF EXISTENTIAL JUSTICE

Resolution No. 492/2023 of the National Council of Justice (Conselho Nacional de Justiça – CNJ) made obligatory the adoption of the Protocol for Judging with a Gender Perspective in all courts of the country. Although its application is more visible in cases of domestic violence or family law, its incidence in Succession Law is fundamental for ensuring the material equality promised by the Federal Constitution.

The protocol is defined not only as a manual of conduct, but as an analytical and interpretive method. It is grounded on the premise that the Law is not neutral and that the blind application of the norm may perpetuate historical injustices.

According to the guidelines of the CNJ, gender is used as a category of analysis to identify how the social constructions of masculinity and femininity create asymmetries of power. As the document points out:

Gender is a category of analysis that allows the understanding of social relations from a critical perspective, revealing the inequalities and hierarchies that are established from a social and cultural construction about what it is to be a man and what it is to be a woman (Brasil, 2021, p. 28).

To judge with a gender perspective in probate and succession means to recognize that the formal neutrality of the law may conceal historical injustices. The judge must be attentive to asymmetries of power, to the unequal division of domestic labor, and to the impact of succession decisions on the subsistence of women who, often, do not possess their own patrimony because they dedicated themselves to the care of the family. Estate planning, when it ignores these realities, may be an instrument for the perpetuation of female submission.

The theory of intersectionality, formulated by Kimberlé Crenshaw (1989), teaches that oppressions are not isolated, but overlap. Intersectionality demonstrates that categories such as gender, race, social class, sexuality, disability, and nationality do not act in isolation, but interconnect and mutually reinforce each other, creating matrices of domination that shape individual and collective experiences.

In Succession Law, this manifests itself when we analyze the situation of a Black, elderly, low-income widow. Her vulnerability is multidimensional. The estate planning of rich families uses holding companies and offshores, while the planning of poor families is often the absence of any instrument, leading to interminable probate proceedings that consume the little existing patrimony.

Intersectionality requires that the operator of succession law consider the social and racial context of the heirs. The exclusion of the spouse as a forced heir, proposed by Bill No. 4/2025, affects far more severely the women of the popular classes, who depend on state protection and on the partner's inheritance so as not to fall into absolute misery after widowhood.

The proposal to remove the spouse from the list of forced heirs is the point of greatest tension with the Gender Protocol. In Brazil, unpaid care work is performed mostly by women. This work allows the male partner to accumulate patrimony, while the woman sacrifices her career and her social security.

By allowing the testator to exclude the spouse from the succession, Bill No. 4/2025 ignores that the surviving spouse's inheritance is, in many cases, a form of deferred compensation for the care work provided over decades. Without the protection of the forced portion, the widow may be evicted from the property where she lived her whole life (except for the real right of habitation, which the bill maintains, but with limitations) and be left without resources for her basic maintenance. Therefore, the expansion of private autonomy, without

mechanisms of financial or alimentary compensation, may represent a setback in women's rights.

The invisibility of care work is one of the pillars of gender inequality. Classical Civil Law, focused on the circulation of goods, does not attribute direct economic value to affection and care. However, in contemporary estate planning, the possibility of including care-legacy clauses begins to be discussed, where the testator recognizes and specifically remunerates the heir (generally a daughter or wife) who dedicated themselves to their support in old age.

The recognition of this work must be an interpretive guideline. If Bill No. 4/2025 is approved, the courts must use the Gender Protocol to annul testamentary provisions that are manifestly abusive or that place the partner in a situation of indignity, using the general clause of good customs and the social function of the family as brakes on absolute autonomy.

Formal equality—all are equal before the law—is not sufficient in Succession Law. The abstract model of the individual—neutral and a property owner—does not exist in Brazilian social reality. Estate planning must be conceived for subjects situated in their realities of gender, race, and class.

It becomes, however, insufficient to treat the individual in a generic, general, and abstract manner. The specification of the subject of rights is necessary, who comes to be seen in their peculiarity and particularity. From this viewpoint, certain subjects of rights or certain violations of rights demand a specific and differentiated response [...]. This means that difference would no longer be used for the annihilation of rights, but, on the contrary, for their promotion (Piovesan, 2005, p. 46).

The feminist critique of Civil Law points out that the freedom to make a will, without social limits, is the freedom of the patriarch to maintain control over the destiny of the family. Democratic estate planning must be a process of family dialogue and not a unilateral imposition. Succession justice requires that private autonomy be exercised with social responsibility, ensuring that the death of the owner of the patrimony is not the beginning of the economic ruin of their vulnerable dependents.

Estate planning must be re-signified as a true instrument of legal protection, overcoming the merely fiscalist view centered on tax saving. Its primary objective comes to be the guarantee of security and dignity of the subjects in a situation of vulnerability within the family.

In this context, the adoption of specific mechanisms proves possible, such as the creation of reserve funds intended for the protection of children with disabilities, the institution of a lifelong usufruct in favor of the surviving spouse, the insertion of clauses of temporary inalienability with the aim of safeguarding spendthrift heirs (*herdeiros pródigos*), and, further,

the establishment of pensions or legacies of an alimentary nature, ensuring the subsistence of those who depended economically on the author of the inheritance. In this way, estate planning assumes an existential and protective function, aligning itself with the constitutional values of the dignity of the human person and of family solidarity.

In view of the changes proposed by Bill No. 4/2025, the role of the lawyer and the notary becomes even more relevant. They must act as ethical advisors, alerting the client to the risks of excluding heirs and proposing balanced solutions.

An effective strategy is the use of life insurance and private pension plans with specific beneficiaries, which ensure immediate liquidity without depending on the probate process. Another tool is the donation with a charge (*doação com encargo*), where the donor transfers the asset but imposes on the donee the obligation to care for a vulnerable third party. These strategies allow autonomy to be exercised in such a way as to promote family solidarity.

Family solidarity is a constitutional principle (Arts. 226 and 230 of the Federal Constitution) that must inform all estate planning. It does not mean nullifying the will of the individual, but rather harmonizing it with the duty of mutual support among the members of the family.

The ideal estate planning is that which manages to balance the freedom of the author of the inheritance with the legitimate expectation of the heirs. Solidarity manifests itself in the concern with the future of the family as a whole, preserving not only the patrimony, but the harmony and the affective bonds. Bill No. 4/2025, by giving more weight to autonomy, requires that solidarity be exercised in a voluntary and conscious manner, and not merely by legal imposition.

A rereading of the Brazilian succession system is then proposed, based on three structuring pillars that reorient its purpose in light of a contemporary and constitutional perspective. In the first place, the functionalization of autonomy implies understanding the freedom to make a will not as an end in itself, but as an instrument geared toward the protection of the person and the continuity of a lawful life project.

In the second place, intersectional protection requires that the succession norms be applied in a manner sensitive to the multiple vulnerabilities that may cut across the subjects, especially those related to gender, race, and age. Finally, the primacy of the existential imposes that the destination of the assets be conceived as an expression of the identity, choices, and values of the *de cujus*, ensuring, at the same time, respect for the dignity of the successors.

This rereading allows estate planning to be seen not as a taboo or a cold accounting of assets, but as an act of citizenship and of intergenerational responsibility, capable of promoting social justice within the family nucleus.

5 CONCLUSION

The analysis developed throughout this study allows the conclusion that the Law of Succession in the 21st century can no longer be understood in isolation, detached from the protection of personality rights and from the constitutional principles that govern family and social relationships. The transition from a strictly patrimonialist paradigm to a view that prioritizes the existential over the patrimonial reveals that assets, far from being an end in themselves, act as material and symbolic support for the realization of existential choices, the concretization of life projects, and the preservation of affective and moral legacies.

Estate planning, in this context, consolidates itself as the tool par excellence for the operationalization of this existential autonomy, allowing the individual to organize their succession in such a way as to reflect their identity, their values, and to protect those who make up their nucleus of care and affection.

The innovations proposed by Bill No. 4/2025 represent a significant milestone in the modernization of the Brazilian Civil Code, with respect to debureaucratization and the strengthening of private autonomy. The regulation of succession pacts, the making of the forced portion more flexible, and the inclusion of provisions on digital inheritance and the genetic will are advances that seek to align the legal order with the complexities of Society 5.0.

However, the proposal to exclude the spouse and the partner from the list of forced heirs imposes a warning sign and demands an in-depth reflection. As demonstrated, the application of a formal neutrality of the law, without considering social realities and asymmetries of power, may conceal and perpetuate grave gender injustices, especially in a social context where unpaid care work is mostly female and, often, invisibilized and economically devalued. The freedom to make a will, if exercised in an absolute manner and detached from the ethics of solidarity and social responsibility, runs the risk of becoming an instrument of exclusion and vulnerabilization, contradicting the very foundations of human dignity.

In this sense, the application of the CNJ's Protocol for Judging with a Gender Perspective and the adoption of an intersectional lens prove indispensable for the operator of the Law. Estate planning must be understood not only as a legal act, but as an act of care and social responsibility, which transcends the mere accounting of assets. It is not enough

for the system to be efficient in terms of patrimonial transmission; it must be, above all, fair and equitable. Succession justice requires that the will of the *de cuius* be respected, but that this respect not mean the material or moral abandonment of vulnerable dependents, especially those who contributed in a non-monetary manner to the formation of the family patrimony.

In the final analysis, the future of Brazilian Succession Law resides in the dynamic and constant balance among three structuring pillars: the functionalization of private autonomy, which understands the freedom to make a will as an instrument at the service of the person and of their lawful life project; the intersectional protection of vulnerabilities, which requires that the succession norms be applied in a manner sensitive to the multiple dimensions of oppression (gender, race, class, age) that may cut across the subjects; and the primacy of the existential, which imposes that the destination of the assets be conceived as an expression of the identity, choices, and values of the *de cuius*, ensuring, at the same time, respect for the dignity and the subsistence of the successors.

Only through a civil-constitutional interpretation, which harmonizes individual freedom with the duty of mutual support and intergenerational solidarity, will it be possible to build a succession system that honors the memory of the dead without compromising the dignity and the subsistence of the living, transforming estate planning into a true instrument of emancipation and existential justice.

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REPRODUCTIVE SELF-DETERMINATION AS A FUNDAMENTAL RIGHT: CONTRIBUTIONS OF FEMINIST CONSTITUTIONALISM

A AUTODETERMINAÇÃO REPRODUTIVA COMO DIREITO FUNDAMENTAL: CONTRIBUIÇÕES DO CONSTITUCIONALISMO FEMINISTA

LA AUTODETERMINACIÓN REPRODUCTIVA COMO DERECHO FUNDAMENTAL: CONTRIBUCIONES DEL CONSTITUCIONALISMO FEMINISTA



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ABSTRACT

This article analyses the contribution of feminist constitutionalism to the recognition of reproductive self-determination as a fundamental right in the contemporary Constitutional State. It starts from the premise that classical liberal constitutionalism was built upon an abstract and universal conception of the legal subject, which rendered women's experiences invisible and contributed to the reproduction of gender inequalities. The research investigates how feminist constitutionalism enables the reconstruction of the constitutional categories of liberty, equality and human dignity, allowing the recognition of women's reproductive autonomy as an essential dimension of fundamental rights. The article argues that reproductive self-determination constitutes an implicit fundamental right derived from the interaction between human dignity, substantive equality and existential freedom. The study adopts a deductive method based on bibliographical and documentary research, drawing upon feminist theory, contemporary constitutional theory and fundamental rights scholarship. It concludes that feminist constitutionalism provides theoretical tools capable of exposing the limitations of traditional constitutional interpretations and supporting the recognition of reproductive autonomy as an indispensable element of women's constitutional citizenship.

Keywords: Feminist Constitutionalism. Reproductive Self-determination. Fundamental Rights. Human Dignity. Gender Equality.

RESUMO

O presente artigo analisa a contribuição do constitucionalismo feminista para o reconhecimento da autodeterminação reprodutiva como direito fundamental no Estado Constitucional contemporâneo. Parte-se da constatação de que o constitucionalismo liberal clássico foi estruturado a partir de uma concepção abstrata e universal de sujeito de direito que invisibilizou experiências femininas e contribuiu para a reprodução de desigualdades de gênero. O problema de pesquisa consiste em investigar de que forma o constitucionalismo feminista possibilita a reconstrução das categorias constitucionais de liberdade, igualdade e dignidade humana, permitindo o reconhecimento da autonomia reprodutiva das mulheres como dimensão essencial dos direitos fundamentais. Sustenta-se a hipótese de que a autodeterminação reprodutiva constitui direito fundamental implícito decorrente da interação entre os princípios da dignidade da pessoa humana, da igualdade substancial e da liberdade existencial. Utiliza-se o método dedutivo, mediante pesquisa bibliográfica e documental, com

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base em referenciais da teoria feminista, da teoria constitucional contemporânea e dos estudos sobre direitos fundamentais. Conclui-se que o constitucionalismo feminista oferece instrumentos teóricos aptos a revelar as limitações das leituras tradicionais da Constituição e a fundamentar o reconhecimento da autonomia reprodutiva como elemento indispensável à cidadania constitucional das mulheres.

Palavras-chave: Constitucionalismo Feminista. Autodeterminação Reprodutiva. Direitos Fundamentais. Dignidade Humana. Igualdade de Gênero.

RESUMEN

El presente artículo analiza la contribución del constitucionalismo feminista para el reconocimiento de la autodeterminación reproductiva como derecho fundamental en el Estado Constitucional contemporáneo. Se parte de la constatación de que el constitucionalismo liberal clásico fue estructurado a partir de una concepción abstracta y universal de sujeto de derecho que invisibilizó experiencias femeninas y contribuyó a la reproducción de desigualdades de género. El problema de investigación consiste en indagar de qué forma el constitucionalismo feminista posibilita la reconstrucción de las categorías constitucionales de libertad, igualdad y dignidad humana, permitiendo el reconocimiento de la autonomía reproductiva de las mujeres como dimensión esencial de los derechos fundamentales. Se sostiene la hipótesis de que la autodeterminación reproductiva constituye un derecho fundamental implícito derivado de la interacción entre los principios de la dignidad de la persona humana, de la igualdad sustancial y de la libertad existencial. Se utiliza el método deductivo, mediante investigación bibliográfica y documental, con base en referentes de la teoría feminista, de la teoría constitucional contemporánea y de los estudios sobre derechos fundamentales. Se concluye que el constitucionalismo feminista ofrece instrumentos teóricos capaces de revelar las limitaciones de las lecturas tradicionales de la Constitución y de fundamentar el reconocimiento de la autonomía reproductiva como elemento indispensable para la ciudadanía constitucional de las mujeres.

Palabras clave: Constitucionalismo Feminista. Autodeterminación Reprodutiva. Derechos Fundamentales. Dignidad Humana. Igualdad de Género.

1 INTRODUCTION

The consolidation of contemporary constitutionalism and the expansion of catalogues of fundamental rights have not been sufficient to eliminate the inequalities historically experienced by women. Although modern democratic constitutions are frequently presented as universal instruments for the protection of liberty, equality and human dignity, feminist criticism has shown that such categories were constructed on the basis of predominantly masculine reference points, producing mechanisms of exclusion that continue to influence the interpretation and application of law.

Classical liberal constitutionalism developed under the premise of the existence of an abstract subject of rights, formally universal and neutral. Historical experience, however, shows that this universal subject corresponded, to a large extent, to the white, heterosexual and economically privileged male experience. As a consequence, various dimensions of women's lives remained for centuries relegated to the private sphere, removed from effective constitutional protection and subjected to mechanisms of legal, social and moral control.

Among the issues that most clearly reveal this dynamic, reproduction stands out. Sexuality, motherhood and the control of women's reproductive capacity were historically regulated by legal and social institutions that limited women's autonomy and made their life projects conditional upon expectations previously defined by patriarchal structures. In this context, reproductive self-determination emerges as one of the principal categories of analysis for understanding the tensions between formal equality and substantive equality in the contemporary Constitutional State.

It is precisely against this backdrop that feminist constitutionalism arises. More than a thematic strand of constitutional theory, feminist constitutionalism constitutes a project of critical reconstruction of the fundamental categories of constitutional law. Its aim is not merely to broaden the legal protection of women, but to question the very epistemological assumptions that underpin the production and interpretation of law.

The research problem guiding this work consists in investigating how feminist constitutionalism contributes to the recognition of reproductive self-determination as a fundamental right in the contemporary Constitutional State.

The starting hypothesis is that feminist constitutional theory promotes a critical rereading of the traditional categories of liberty, equality and human dignity, making it possible to recognise reproductive autonomy as an essential dimension of women's constitutional citizenship. From this perspective, reproductive rights cease to be understood as merely private or moral matters and come to form part of the fundamental core of human rights.

The general objective is to analyse the theoretical foundations of feminist constitutionalism and its contribution to the recognition of reproductive self-determination as a fundamental right. Specifically, the aim is to examine the feminist critiques of the universal subject of liberal constitutionalism; to identify the main theoretical contributions to the reconstruction of traditional constitutional categories; and to investigate how such contributions provide a basis for recognising women's reproductive autonomy.

The relevance of the research is justified by the centrality assumed by debates concerning reproductive rights in contemporary constitutional democracies. In different legal systems, controversies relating to the voluntary termination of pregnancy, assisted reproduction, family planning and bodily autonomy continue to reveal tensions between fundamental rights, moral values and historical structures of gender inequality.

1.1 METHODOLOGICAL ASPECTS

The research is conducted by means of the deductive method, starting from the analysis of the theoretical categories of feminist constitutionalism in order to examine its contribution to the recognition of reproductive self-determination as a fundamental right. Bibliographical and documentary research is used, with a qualitative approach and an exploratory-explanatory character.

The theoretical framework is based on central female and male authors of feminist theory, contemporary constitutional theory and fundamental rights scholarship. Among them, John Stuart Mill, Simone de Beauvoir, Catharine MacKinnon, Kimberlé Crenshaw, Judith Butler, Martha Nussbaum, Beverley Baines, Daphne Barak-Erez, Tsvi Kahana, Laura Ronchetti and Simone Penasa stand out.

The analysis seeks to articulate contributions produced in different national contexts, especially in Brazil and Italy, making it possible to identify theoretical points of convergence and common challenges relating to the constitutional protection of women's reproductive autonomy.

2 THE FEMINIST CRITIQUE OF THE UNIVERSAL SUBJECT OF LIBERAL CONSTITUTIONALISM

2.1 JOHN STUART MILL AND THE DENUNCIATION OF WOMEN'S LEGAL SUBORDINATION

Although feminist constitutionalism is a contemporary phenomenon, its foundations can be identified in reflections developed as early as the nineteenth century. Among the

authors who contributed to the construction of an initial critique of legal inequality between men and women, John Stuart Mill stands out.

In *The Subjection of Women* (1869), Mill formulates one of the most forceful critiques of women's legal subordination found in classical liberal thought. By maintaining that the legal subjection of women constitutes one of the principal obstacles to human progress, the author breaks with naturalising conceptions that justified gender inequality on the basis of supposed biological or moral differences between the sexes.

Mill's contribution goes beyond the mere defence of formal equality. His central argument is that every limitation of human liberty requires rational justification compatible with the principles of justice. From this perspective, the exclusion of women from spaces of civil autonomy, political participation and the full exercise of citizenship could not be legitimised by traditions, customs or historically established social conventions.

By shifting the debate to the field of the legal and political justification of inequalities, Mill inaugurates an important line of reflection later deepened by contemporary feminist theories. Inequality between men and women ceases to be conceived as a natural phenomenon and comes to be understood as the result of social and institutional constructions susceptible to transformation.

The relevance of this perspective for feminist constitutionalism lies precisely in the possibility of questioning the naturalisation of social roles attributed to women. Questions relating to motherhood, sexuality and reproduction cease to be understood as inevitable expressions of feminine nature and come to be analysed as phenomena historically conditioned by relations of power and specific normative structures.

2.2 SIMONE DE BEAUVOIR AND THE CONSTRUCTION OF WOMAN AS THE "OTHER"

The critique of women's subordination gains theoretical depth in the twentieth century with *Le Deuxième Sexe*, published by Simone de Beauvoir in 1949. Regarded as one of the founding texts of contemporary feminism, the work breaks with biologising explanations of inequality between men and women and demonstrates that the feminine condition is the result of historical, social and cultural processes of the construction of difference.

The celebrated assertion that "one is not born, but rather becomes, a woman" synthesises the author's critique of the naturalisation of gender roles. For Beauvoir, the characteristics traditionally associated with femininity do not derive from an immutable biological essence, but from social mechanisms that shape behaviours, expectations and possibilities of existence.

In this context, the author develops the notion of otherness, according to which woman was historically constituted as the “Other”. While man was identified with universality, rationality and the condition of subject, woman was defined in a relational manner, as a being dependent on and complementary to the masculine. Man became the measure of the human; woman, his difference.

The importance of this formulation for constitutional theory is significant. If the universal subject of law was constructed on the basis of the masculine experience, then apparently neutral legal categories come to reflect masculine values, interests and perspectives. Constitutional neutrality thus reveals itself to be an apparent neutrality.

This critique has particular relevance for understanding reproductive autonomy. The historical construction of woman as the “Other” was directly associated with her identification with motherhood and with reproductive functions. Reproduction was frequently presented not as a possibility of personal fulfilment, but as an obligatory social destiny. Women’s autonomy over their own bodies remained conditioned by collective expectations relating to the family, morality and the preservation of particular social models.

From the perspective inaugurated by Beauvoir, the constitutional recognition of reproductive self-determination represents an indispensable condition for overcoming this logic of otherness. Only when women are recognised as full subjects of rights, capable of deciding autonomously about their existential projects, does it become possible to give effect to the constitutional ideals of liberty, equality and human dignity.

2.3 CATHARINE MACKINNON AND THE CRITIQUE OF STATE NEUTRALITY

The reflections developed by Simone de Beauvoir find important deepening in the work of Catharine MacKinnon. Unlike Beauvoir, whose analysis focuses on the processes of the social construction of inequality, MacKinnon directs her critique at the functioning of legal and political institutions.

In *Toward a Feminist Theory of the State* (1989), the author maintains that the liberal State is not neutral. On the contrary, its normative structures were historically constructed from the masculine perspective and contribute to the reproduction of relations of gender domination. Law does not merely reflect pre-existing social inequalities; it actively participates in their maintenance.

According to MacKinnon, the formal equality promoted by liberal constitutionalism proves insufficient because it ignores the concrete conditions of subordination that affect women. The mere abstract attribution of rights does not eliminate the historical relations of power that limit the effective exercise of liberty and autonomy.

This critique has profound implications for understanding reproductive rights. The legal regulation of sexuality, motherhood and reproduction is frequently presented as the protection of collective interests or universal values. Feminist analysis, however, shows that such normative choices bear disproportionately on female bodies, restricting spaces of autonomy and reinforcing patriarchal structures.

MacKinnon's contribution makes it possible to understand that reproductive self-determination cannot be analysed exclusively from the standpoint of individual liberty. It is also a matter relating to the distribution of power in societies historically marked by gender inequalities. The recognition of reproductive autonomy therefore represents an instrument for the promotion of substantive equality and for confronting the institutional forms of women's subordination.

3 INTERSECTIONALITY, PERFORMATIVITY AND CONSTITUTIONAL RECONSTRUCTION

3.1 KIMBERLÉ CRENSHAW AND THE CRITIQUE OF THE UNIVERSALISATION OF WOMEN'S EXPERIENCE

The development of contemporary feminist constitutionalism was profoundly influenced by the theory of intersectionality formulated by Kimberlé Crenshaw. In analysing the situation of Black women in the United States, the author demonstrated that traditional models for combating discrimination were incapable of understanding experiences marked by the overlapping of multiple systems of oppression.

The main contribution of intersectionality consists in showing that gender, race, social class, sexual orientation and other social markers do not operate in isolation. On the contrary, they interact simultaneously, producing specific forms of exclusion that cannot be understood through fragmented analyses.

The critique formulated by Crenshaw is directed both at traditional anti-discrimination law and at certain feminist currents that universalised the experience of white middle-class women as the paradigm of the feminine condition. By ignoring differences internal to the group of women itself, these approaches ended up rendering invisible specific forms of oppression experienced by historically marginalised groups.

In the field of reproductive rights, intersectionality reveals that the obstacles to the exercise of bodily autonomy are not distributed uniformly. Black, poor, Indigenous, migrant women and women belonging to vulnerabilised groups frequently face significantly more severe barriers to accessing health services, information and the means necessary for the exercise of their reproductive rights.

The theory of intersectionality broadens the scope of feminist constitutionalism by requiring that the protection of fundamental rights be constructed on the basis of the plurality of women's experiences. Constitutional equality ceases to be conceived as mere uniform treatment and comes to require the recognition of the differences and structural inequalities that affect particular social groups.

3.2 JUDITH BUTLER AND THE DECONSTRUCTION OF NORMATIVE IDENTITIES

The feminist critique of traditional gender structures reaches a new level with the work of Judith Butler. In *Gender Trouble* (1990), the author questions essentialist conceptions of identity and develops the theory of gender performativity.

According to Butler, gender identities do not constitute natural or biologically determined realities. They are produced and reproduced by reiterated social practices that establish normative expectations about individuals. Gender does not precede experience; it is continuously constructed through discourses, institutions and social practices.

This perspective has important implications for constitutional theory. By demonstrating that apparently natural categories are, in reality, historical and cultural constructions, Butler highlights the need to revise legal models founded on rigid and binary conceptions of human identity.

In the sphere of reproductive self-determination, the theory of performativity makes it possible to understand that the legal control of reproduction is frequently associated with the imposition of particular social roles on women. Motherhood ceases to be understood merely as an individual choice and comes to be analysed as a social expectation produced by normative structures that associate femininity with reproduction.

Consequently, the constitutional protection of reproductive autonomy requires not only the formal recognition of rights, but also the deconstruction of normative patterns that condition women's choices and limit their possibilities of self-determination.

3.3 MARTHA NUSSBAUM AND THE CAPABILITIES APPROACH

The feminist reconstruction of the constitutional categories of liberty and equality finds an important normative foundation in the capabilities approach developed by Martha Nussbaum.

Distancing herself from strictly formal conceptions of justice, Nussbaum proposes a model oriented towards the effective promotion of the conditions necessary for each individual to develop their human potential fully. The author maintains that human dignity

requires more than the mere abstract holding of rights. It is necessary that people have real conditions to make meaningful choices relating to their life projects.

Among the capabilities considered fundamental by the author, bodily health, physical integrity, practical autonomy and freedom of choice in reproductive matters stand out. These capabilities constitute indispensable prerequisites for human flourishing and for the effective exercise of citizenship.

The relevance of this formulation for feminist constitutionalism lies in overcoming the traditional understanding of liberty as the mere absence of state interference. Liberty comes to be understood as the effective possibility of acting, deciding and autonomously constructing one's own life project.

From this perspective, reproductive self-determination is not limited to the formal recognition of the right of choice. It requires material conditions that allow women to exercise such a choice in a free, informed and responsible manner. Economic, social and cultural barriers can render illusory a formally guaranteed liberty, which is why the constitutional protection of reproductive rights also demands public policies oriented towards the promotion of substantive equality.

4 FEMINIST CONSTITUTIONALISM AND REPRODUCTIVE SELF-DETERMINATION

The theoretical contributions examined above converge on a central question: the need to reconstruct the traditional constitutional categories on the basis of women's concrete experiences. It is precisely in this context that the relationship between feminist constitutionalism and reproductive self-determination emerges.

Historically, legal systems exercised significant control over female sexuality, motherhood and reproduction. Women's reproductive capacity was frequently treated as an object of state, religious or moral regulation, limiting spaces of individual autonomy and making life projects conditional upon previously established expectations.

Feminist constitutionalism shows that such limitations cannot be understood as mere neutral legislative options. They reflect historical structures of power that associated feminine identity with motherhood and attributed to women specific social functions relating to reproduction and care.

In this scenario, reproductive self-determination arises as a constitutional category intended to protect women's capacity to decide about fundamental aspects of their existence. It is the prerogative to decide, in a free, informed and responsible manner, on questions relating to sexuality, contraception, motherhood, assisted reproduction and other dimensions of reproductive life.

4.1 REPRODUCTIVE SELF-DETERMINATION AS AN IMPLICIT FUNDAMENTAL RIGHT

The discussion developed thus far makes it possible to advance towards a central question: does reproductive self-determination constitute merely a doctrinal construction, or can it be recognised as a genuine fundamental right in contemporary constitutionalism? The answer proposed in this work is affirmative.

Although the 1988 Constitution of the Federative Republic of Brazil does not expressly mention the expression “reproductive self-determination”, the absence of a specific textual provision does not preclude its constitutional recognition. On the contrary, the very logic of contemporary constitutionalism admits the existence of implicit fundamental rights derived from the structuring principles of the constitutional order.

The clause of material openness set out in Article 5, § 2, of the Federal Constitution establishes that the rights and guarantees expressly provided for in the constitutional text do not exclude others derived from the regime and the principles it adopts. This provision makes it possible to recognise fundamental rights that are not expressly enumerated, provided that they can be drawn from the axiological structure of the Constitution.

In this context, reproductive self-determination finds its foundation, in the first place, in human dignity, enshrined in Article 1, item III, of the Federal Constitution. Dignity presupposes the recognition of each individual as an autonomous moral subject, capable of defining the fundamental course of their own existence. Decisions relating to sexuality, motherhood, family planning and reproduction fall within the most intimate core of personal autonomy, which is why they cannot be reduced to mere objects of state protection or of heteronomous moral impositions.

In the second place, reproductive self-determination derives from the principle of liberty. Constitutional liberty is not limited to the absence of physical or legal coercion, equally encompassing the possibility of autonomously constructing one’s own life projects. From this perspective, the choice to have children, not to have them, to resort to techniques of assisted reproduction or to exercise other faculties relating to reproductive life forms part of the sphere of constitutionally protected existential liberty.

Substantive equality also constitutes an indispensable foundation for the recognition of reproductive autonomy. Historically, the legal and social control of reproduction bore predominantly on female bodies, producing specific restrictions on women’s liberty. Consequently, giving effect to equality requires the recognition of spaces of autonomy capable of neutralising structural mechanisms of gender subordination.

In addition, family planning, expressly provided for in Article 226, § 7, of the Federal Constitution, offers important normative support for the recognition of reproductive self-

determination. By establishing that family planning constitutes the free decision of the couple, prohibiting any coercive form on the part of official or private institutions, the constituent power incorporated into the constitutional text the idea of reproductive liberty as a legally protected value.

Reproductive self-determination also finds support in the rights to health, to intimacy and to private life, all directly related to the protection of bodily autonomy and the individual sphere of decision. It is, therefore, a right that emerges from the systematic interpretation of the Constitution, articulating multiple fundamental principles and guarantees.

Luigi Ferrajoli's guarantist theory reinforces this understanding by maintaining that fundamental rights constitute limits on the arbitrary exercise of power and instruments for the protection of individual autonomy. From this perspective, the constitutional protection of reproductive self-determination does not represent a mere state concession, but a guarantee intended to ensure spaces of liberty indispensable to the development of the human personality.

From the standpoint of feminist constitutionalism, this recognition acquires an even deeper significance. Reproductive autonomy represents not only a manifestation of individual liberty, but also an instrument for confronting the historical structures that made female citizenship conditional upon the control of sexuality and motherhood. For this reason, reproductive self-determination must be understood as a genuine implicit fundamental right, indispensable to giving effect to the human dignity, substantive equality and existential liberty of women.

5 BRAZILIAN AND ITALIAN PERSPECTIVES ON FEMINIST CONSTITUTIONALISM

5.1 BRAZILIAN FEMINIST CONSTITUTIONALISM

In the Brazilian context, feminist constitutionalism has consolidated itself as an important field of academic production and constitutional critique, especially after the promulgation of the 1988 Constitution. The incorporation of the principles of human dignity, equality and non-discrimination allowed the development of new constitutional readings oriented towards overcoming historical structures of exclusion.

The work *Constitucionalismo Feminista*, coordinated by Christine Peter, Estefânia Barboza, Melina Girardi Fachin and Bruna Nowak, represents a fundamental milestone of this movement. The authors demonstrate that traditional constitutional theory was constructed on the basis of masculine paradigms, producing structural exclusions and rendering invisible women's experiences in the spaces of normative production and constitutional interpretation.

From this perspective, Brazilian feminist constitutionalism is not limited to the formal inclusion of women in the legal system. Its aim is to promote a hermeneutic reconstruction of the classical constitutional categories, incorporating the gender perspective as an indispensable element for understanding fundamental rights.

Bodily autonomy and reproductive rights occupy a central position in this process. The recognition of women as full subjects of rights requires that decisions relating to sexuality, motherhood and reproduction be analysed in the light of human dignity, substantive equality and existential liberty.

5.2 ITALIAN FEMINIST CONSTITUTIONALISM

The Italian experience presents equally relevant contributions to the development of contemporary feminist constitutionalism. Italian doctrine has emphasised the need to confront critically the constitutional tradition founded on abstract conceptions of universality, demonstrating how the exclusion of women's experiences compromises the effectiveness of the constitutional principles of equality and dignity.

In this context, the production of Laura Ronchetti stands out, denouncing the rendering invisible of sexual difference in Italian legal science and proposing a rapprochement between constitutionalism and feminist thought. For the author, giving effect to the constitutional project requires confronting the structural inequalities that continue to limit women's liberty.

Ronchetti's reflection proves particularly relevant to the theme of reproductive self-determination. In critically analysing mechanisms of legal control over female reproduction, the author demonstrates that bodily autonomy constitutes an essential dimension of democratic citizenship and of substantive equality.

The contribution of Simone Penasa also deserves mention, especially in his analyses of medically assisted reproduction and surrogacy. His work highlights the need to interpret complex bio-legal questions on the basis of the fundamental rights involved, avoiding moralising reductions that obscure the centrality of individual autonomy and human dignity.

5.3 CONVERGENCES BETWEEN THE BRAZILIAN AND ITALIAN MODELS

Despite the historical, cultural and institutional differences existing between Brazil and Italy, the reflections produced in both contexts present important points of convergence.

In the first place, a common critique is observed of the figure of the abstract universal subject that marked the development of liberal constitutionalism. Both Brazilian and Italian doctrine show that the alleged neutrality of constitutional law frequently conceals masculine perspectives presented as universal.

In the second place, both models recognise the need to incorporate women's concrete experiences into constitutional interpretation. Equality ceases to be understood exclusively from a formal perspective and comes to require confronting the structural inequalities that limit female autonomy.

Finally, the two traditions converge in the understanding that reproductive self-determination forms part of the essential core of women's fundamental rights. Even though the legal orders adopt distinct solutions for specific questions, there is a growing recognition of the need to protect bodily autonomy constitutionally as a condition for giving effect to human dignity, liberty and substantive equality.

5.4 THE DIALOGUE BETWEEN FEMINIST CONSTITUTIONALISMS IN BRAZIL AND ITALY

The comparative analysis developed throughout this work shows that Brazil and Italy share similar challenges with regard to the constitutional protection of women's autonomy, although situated in distinct historical and institutional contexts.

Both countries adopt constitutional models strongly committed to human dignity, equality and the protection of fundamental rights. In both cases, however, giving effect to these principles continues to face obstacles relating to the persistence of patriarchal structures that influence the interpretation and application of law.

In Brazil, debates concerning the voluntary termination of pregnancy, family planning, assisted reproduction and sexual rights reveal permanent tensions between individual autonomy and moralising perspectives on reproduction. In Italy, controversies relating to the effectiveness of Law No. 194/1978, to conscientious objection and to the limitations imposed by Law No. 40/2004 demonstrate similar challenges regarding the effective guarantee of women's reproductive liberty.

In this scenario, feminist constitutionalism offers an important space for transnational dialogue. The Brazilian and Italian experiences demonstrate that the protection of women's fundamental rights does not depend exclusively on specific legislative solutions, but also on the construction of interpretative models capable of incorporating the gender perspective into constitutional hermeneutics.

The circulation of legal arguments, the doctrinal exchange and the dialogue between constitutional courts contribute to the formation of common parameters for the protection of bodily and reproductive autonomy. This is a process that strengthens the understanding of reproductive self-determination as an essential dimension of women's human rights and as an integral element of the contemporary democratic constitutional heritage.

6 CONCLUSION

The analysis developed throughout this article has made it possible to demonstrate that feminist constitutionalism represents one of the most relevant theoretical contributions to the renewal of contemporary constitutional thought. By questioning the alleged neutrality of classical liberal constitutionalism, feminist theory shows that fundamental categories such as liberty, equality and dignity were historically formulated on the basis of masculine reference points, producing mechanisms of exclusion that directly affected the legal condition of women.

The contributions of John Stuart Mill, Simone de Beauvoir, Catharine MacKinnon, Kimberlé Crenshaw, Judith Butler and Martha Nussbaum reveal a progressive process of broadening the feminist critique of law, making it possible to understand how legal and institutional structures participate in the reproduction of gender inequalities.

In this context, reproductive self-determination emerges as a privileged expression of the transformations promoted by feminist constitutionalism. More than a simple manifestation of individual liberty, it constitutes an essential dimension of human dignity, substantive equality and women's constitutional citizenship.

The analysis of the Brazilian and Italian experiences reinforces this conclusion by demonstrating that the incorporation of the gender perspective into constitutional interpretation represents an indispensable condition for giving effect to fundamental rights. In both contexts, the protection of reproductive autonomy proves to be a fundamental instrument for overcoming normative structures historically marked by patriarchy.

It is concluded, therefore, that feminist constitutionalism offers consistent theoretical foundations for the recognition of reproductive self-determination as an implicit fundamental right. By critically reconstructing the traditional constitutional categories, this perspective contributes to the consolidation of a constitutional order genuinely committed to the liberty, equality and dignity of all persons.

From this perspective, the constitutional recognition of reproductive self-determination does not represent the creation of a new right, but the unveiling of a guarantee already contained in the democratic constitutional order, the effectiveness of which remains conditional upon overcoming legal and social structures historically marked by gender inequality.

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CREDIT COOPERATIVISM AND REGIONAL DEVELOPMENT: EVIDENCE FROM A SYSTEMATIC LITERATURE REVIEW

COOPERATIVISMO DE CRÉDITO E DESENVOLVIMENTO REGIONAL: EVIDÊNCIAS DE UMA REVISÃO SISTEMÁTICA DA LITERATURA

COOPERATIVISMO DE CRÉDITO Y DESARROLLO REGIONAL: EVIDENCIAS DE UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA



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ABSTRACT

Credit cooperativism has been widely recognised as an instrument of financial inclusion and of the promotion of regional development. Given the growing scientific output on the subject, it becomes relevant to understand how the literature has addressed the relationship between credit cooperativism and regional development. In this context, this study aims to analyse the scientific output related to the theme by means of a systematic literature review. The search was carried out in national and international databases, covering studies that address credit cooperativism, financial inclusion and regional development. The results show that the literature focuses mainly on the analysis of the contribution of cooperatives to local development, the expansion of access to financial services and the strengthening of regional economies. A predominance of descriptive studies was also observed, as well as a geographical concentration of the research in regions where cooperativism presents a greater degree of institutional consolidation. As a contribution, the study systematises the knowledge produced on the subject and identifies gaps that may guide future research agendas.

Keywords: Credit Cooperativism. Regional Development. Financial Inclusion. Systematic Literature Review. Local Development.

RESUMO

O cooperativismo de crédito tem sido amplamente reconhecido como um instrumento de inclusão financeira e de promoção do desenvolvimento regional. Diante da crescente produção científica sobre o tema, torna-se relevante compreender como a literatura tem abordado a relação entre cooperativismo de crédito e desenvolvimento regional. Nesse contexto, este estudo tem como objetivo analisar a produção científica relacionada ao tema por meio de uma revisão sistemática da literatura. A busca foi realizada em bases de dados nacionais e internacionais, contemplando estudos que abordam cooperativismo de crédito, inclusão financeira e desenvolvimento regional. Os resultados evidenciam que a literatura concentra-se principalmente na análise da contribuição das cooperativas para o desenvolvimento local, ampliação do acesso aos serviços financeiros e fortalecimento das economias regionais. Observou-se ainda predominância de estudos descritivos e concentração geográfica das pesquisas em regiões onde o cooperativismo apresenta maior

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grau de consolidação institucional. Como contribuição, o estudo sistematiza o conhecimento produzido sobre o tema e identifica lacunas que podem orientar futuras agendas de pesquisa.

Palavras-chave: Cooperativismo de Crédito. Desenvolvimento Regional. Inclusão Financeira. Revisão Sistemática da Literatura. Desenvolvimento Local.

RESUMEN

El cooperativismo de crédito ha sido ampliamente reconocido como un instrumento de inclusión financiera y de promoción del desarrollo regional. Ante la creciente producción científica sobre el tema, resulta relevante comprender cómo la literatura ha abordado la relación entre cooperativismo de crédito y desarrollo regional. En este contexto, este estudio tiene como objetivo analizar la producción científica relacionada con el tema por medio de una revisión sistemática de la literatura. La búsqueda se realizó en bases de datos nacionales e internacionales, contemplando estudios que abordan el cooperativismo de crédito, la inclusión financiera y el desarrollo regional. Los resultados evidencian que la literatura se concentra principalmente en el análisis de la contribución de las cooperativas al desarrollo local, la ampliación del acceso a los servicios financieros y el fortalecimiento de las economías regionales. Se observó además un predominio de estudios descriptivos y una concentración geográfica de las investigaciones en regiones donde el cooperativismo presenta un mayor grado de consolidación institucional. Como contribución, el estudio sistematiza el conocimiento producido sobre el tema e identifica lagunas que pueden orientar futuras agendas de investigación.

Palabras clave: Cooperativismo de Crédito. Desarrollo Regional. Inclusión Financiera. Revisión Sistemática de la Literatura. Desarrollo Local.

1 INTRODUCTION

The Central Bank of Brazil (BCB, 2024) defines a Credit Cooperative as a financial institution formed by the association of people whose aim is to provide financial services exclusively to its members. In them, members find the main services available in banks, that is, current accounts, financial investments, credit cards, loans and financing.

The distinctive feature of credit cooperatives occurs when the cooperative's positive result, known as the surplus, is shared with the member in proportion to the financial operations carried out with the institution. The Central Bank of Brazil (BCB, 2025) further stresses that the member must also be prepared for a possible apportionment in the event of losses, which is likewise calculated according to the use of services.

Credit cooperativism in Brazil constitutes one of the most dynamic and structured segments of the national cooperative system. According to data from the Organisation of Brazilian Cooperatives (OCB, 2024), the country has more than 25 million members and more than 4,000 active cooperatives. The credit branch, in turn, accounts for more than 20 million members, that is, it is one of the largest fields of cooperativism in Brazil. Thus, credit cooperativism stands out as a strategic agent for the economic and social development of Brazil.

The expansion of credit cooperativism in recent decades has occurred unevenly across Brazilian regions. The South and South-east concentrate the largest number of cooperatives, assets and members, reflecting a historical process of institutional and economic consolidation of the sector. By contrast, the North and North-east present lower cooperative density and lower coverage of the financial services offered by these institutions (Schneider, 2015). This regional asymmetry has aroused growing academic interest, especially regarding the potential of credit cooperatives to promote financial inclusion, economic dynamisation and regional development.

Although the subject has aroused growing academic interest in recent decades, the scientific literature still presents important gaps regarding the understanding of the different territorial contexts in which credit cooperativism develops. In addition to the diversity of theoretical and methodological approaches, there is a need to broaden knowledge about the factors that condition the impacts of credit cooperatives on financial inclusion and regional development (Queiroz, Flach and Mattos, 2022).

Against this background, the following research question emerges: How has scientific output addressed the relationship between credit cooperativism and regional development?

Accordingly, this research aims to analyse, by means of a systematic literature review, how scientific output has addressed the relationship between credit cooperativism and

regional development, identifying the main themes investigated, the methodological approaches adopted, the results found and the gaps existing in the literature.

The relevance of this study lies in the systematisation of scientific output on credit cooperativism and regional development. Although the subject has aroused growing academic interest in recent decades, the literature is dispersed across different theoretical approaches, territorial contexts and methodological strategies. In this sense, conducting a systematic review makes it possible to organise the knowledge produced, to identify convergences and divergences between studies, and to highlight gaps still existing in the literature. Among these gaps, the lesser attention devoted to less-studied regions of the country, especially the North and North-east, stands out, reinforcing the need to broaden investigations into the activity of credit cooperatives in different regional contexts.

To achieve this objective, the article is organised into five sections. After this introduction, the theoretical framework on credit cooperativism and regional development is presented. Subsequently, the methodological procedures adopted are described. The main results of the literature review are then discussed and, finally, the study's final considerations are presented.

2 THEORETICAL FRAMEWORK

This section presents the theoretical framework that underpins the analysis of credit cooperativism and its relationship with regional development. Initially, the origin and evolution of credit cooperativism are discussed, highlighting its principles and institutional characteristics. Next, the main theories of regional development that help in understanding territorial inequalities and the role of cooperative organisations in the dynamisation of local economies are addressed. Finally, studies that analyse the activity of credit cooperatives in Brazil are presented, with emphasis on regional asymmetries and the challenges of expanding the model in regions less served by the traditional financial system.

2.1 CREDIT COOPERATIVISM

Credit cooperativism emerged in Brazil at the beginning of the twentieth century, inspired by European experiences of solidarity economy and financial inter-cooperation. Its genesis dates back to 1902, with the founding of the Rural Credit Cooperative of Nova Petrópolis, in Rio Grande do Sul, considered the first in Latin America (Pinho, 2004).

The adoption of cooperativism in Brazil was inspired by the Raiffeisen model (1864), whose characteristics, according to Pinho (2004), are founded on the Christian principle of love for one's neighbour, admit philanthropic assistance, attach great importance to the moral

formation of members—who become jointly and unlimitedly responsible for the obligations contracted by the cooperative—attach significant importance to organising the institution so as to meet the needs of the cooperatives, do not remunerate their directors and did not distribute returns. This first credit cooperative of Nova Petrópolis aimed to bring together small rural producers to offer mutual credit on accessible terms, strengthening the local economy and reducing dependence on traditional financial institutions.

The movement gained strength mainly in communities of German and Italian colonisation, where the culture of cooperation and self-management was already part of social and religious practices (Schneider, 2015). For decades, credit cooperativism remained strongly linked to the rural environment, acting as an instrument of financial inclusion and local development.

The institutionalisation of the sector occurred with the advent of Law No. 5,764 (Brazil, 1971), which defined the National Cooperativism Policy, establishing criteria for the constitution, operation and supervision of cooperatives. It established the legal framework of the Brazilian cooperative movement, consolidating the figure of the cooperative as an autonomous society of people united by common economic and social objectives, distinct from capital-based companies. Subsequently, the 1988 Federal Constitution, in its Article 5, item XVIII, reinforced freedom of association and the autonomy of cooperatives, guaranteeing legal certainty and legitimacy to their activity (Brazil, 1988).

In this regard, Martins (2022) observes that associative freedom in cooperatives must be understood as a right-guarantee, ensuring that individuals with common interests may organise collectively with autonomy and without state intervention. Constitutional recognition reinforces the democratic nature of cooperatives, distinguishing them from business companies and conferring on them reinforced protection within the legal order.

In the 1990s and 2000s, credit cooperativism underwent a process of restructuring and institutional expansion, with the strengthening of integrated systems such as the Cooperative Credit System (Sicredi), the System of Credit Cooperatives of Brazil (Sicoob) and the System of Rural Credit Cooperatives with Solidarity Interaction (Cresol), which broadened the capillarity and diversity of financial products offered to members (Manenti, 2021).

The regulation of the Central Bank of Brazil (BCB), especially after Resolution No. 4,434/2015, was decisive for the increase in the efficiency, transparency and competitiveness of these institutions.

It is important to stress that studies on the management of credit cooperatives indicate that the performance of these organisations depends on the capacity to reconcile administrative efficiency, member participation and financial sustainability. Porto (2002), in

proposing an evaluation model based on the *Balanced Scorecard* for rural credit cooperatives in the north of the country, stresses the importance of managerial instruments capable of aligning strategic objectives, institutional performance and the meeting of members' demands.

Currently, Brazilian credit cooperativism constitutes a relevant segment of the national financial system, being responsible for a portion of the credit operations in the country and showing growing expansion over recent years. According to the Central Bank of Brazil (BCB, 2024), credit cooperatives are present in about 55% of Brazilian municipalities, reaching localities frequently underserved by traditional banks.

In this sense, recent empirical evidence reinforces the role of credit cooperatives not only as instruments of financial inclusion, but also as agents of regional development. Cavinato and Capitani (2023), in analysing the social efficiency of rural credit cooperatives in Brazil from a regional perspective, identify that these institutions have a positive impact above all in less developed regions, contributing to the expansion of access to credit, the strengthening of local productive activities and the reduction of territorial inequalities. The results indicate that the activity of cooperatives goes beyond financial intermediation, assuming a relevant role in economic dynamisation and in the promotion of sustainable regional development.

Having understood the foundations and evolution of credit cooperativism, it becomes necessary to discuss its relationship with regional development, a theme addressed in the following section.

2.2 COOPERATIVISM AND REGIONAL DEVELOPMENT

Classical authors such as Perroux (1950), Myrdal (1957) and Hirschman (1958) emphasise that economic development occurs unevenly across territory, being driven by dynamic poles and cumulative processes.

As Vasconcelos and Leite (2004) emphasise, different classical contributions of the literature on regional development, such as those of Perroux (1950), Myrdal (1957) and Hirschman (1958), although formulated at distinct moments and under varied theoretical approaches, converge in recognising that economic development occurs in a spatially uneven manner, being driven by dynamic sectors and by processes of productive linkage.

The growth poles theory, proposed by Perroux (1950), became one of the main references of the literature on regional development; far from seeking to restrict his theory, this work will restrict the focus to the field of regional planning and development. The analysis is based on the idea that economic growth occurs in a spatially uneven manner, concentrating

in development poles formed by sectors or activities with greater capacity for economic dynamisation. From these poles, the effects of growth spread to other areas through productive linkages and structural transformations in the economy (Campos Junior, 2020).

From this perspective, the concept of pole refers to the presence of activities capable of exerting strong influence over other productive activities, generating effects of diffusion and economic linkage. Thus, development is understood as a process of structural transformation of the economy, marked by the emergence of new industries and by the replacement of less dynamic activities with innovative sectors.

Perroux's (1950) interpretation of the spatial concentration of economic growth dialogues with other classical approaches to regional development. Among them, the theory of circular cumulative causation proposed by Myrdal (1957) stands out, emphasising the tendency towards the concentration of development in certain regions. According to the author, economic processes generate effects that feed back over time, reinforcing already existing territorial inequalities: more developed regions tend to attract investment, infrastructure and human capital, while less favoured areas remain trapped in trajectories of relative stagnation. In this context, the concentration of productive activities can expand employment, income and the local consumer market, creating conditions for the attraction of new economic activities and intensifying the processes of regional polarisation (Oliveira and Teles, 2019; Ferreira and Salles, 2020).

Hirschman (1958), *apud* Vasconcelos and Leite (2004), argues that economic growth occurs in an unbalanced manner, being driven by strategic sectors capable of generating productive linkages. For the authors, these linkages may occur both forward (*forward linkages*), stimulating activities that use the products generated by a given sector, and backward (*backward linkages*), encouraging the emergence of suppliers and inputs necessary for production. Regional development, according to the authors, depends on the capacity of key sectors and regions to create these multiplier effects.

In this way, certain sectors or activities assume a strategic role in the dynamisation of regional economies, by stimulating the expansion of productive chains and generating multiplier effects on other segments of the economy. In this context, cooperatives can play a relevant role by articulating producers, consumers and markets, contributing to the strengthening of local productive chains. Thus, organisations capable of articulating economic agents and stimulating the formation of local productive chains can act as important catalysts of the processes of regional development described by Hirschman (1958).

Taken together, the classical approaches to regional development, represented by the contributions of Perroux (1950), Myrdal (1957) and Hirschman (1958), show that economic

growth has a strong spatial dimension and tends to occur unevenly across regions (Vasconcelos and Leite, 2004). In this context, understanding the mechanisms capable of promoting greater territorial balance becomes fundamental for the analysis of regional development strategies.

In the Brazilian case, these dynamics of concentration and diffusion of economic growth manifest themselves particularly clearly in the historical inequalities between the different regions of the country. Owing to asymmetries in infrastructure, human capital and access to opportunities, the inequalities are aggravated by the historical concentration of public and private investment in the South–South-east axis (Vargas-Chaves, 2021). For this author, human capital, understood as the technical and organisational qualification of the population, is a determining factor for the success of cooperatives, which depend on the training and engagement of their members in order to operate efficiently and sustainably.

In more recent approaches, it is perceived that endogenous territorial development emphasises the valorisation of local potential, participatory governance and institutional networks. Authors such as Putnam (1993) and Vázquez Barquero (2002) highlight the role of social capital, trust and cooperation in promoting sustainable development. For Putnam (1993), social capital, understood as the set of networks of trust, norms of reciprocity and civic participation, constitutes a fundamental element for the strengthening of institutions and for the coordination of collective actions at the local level. Vázquez Barquero (2002), in turn, emphasises that territorial development depends on the capacity of communities to mobilise their internal resources, articulate local actors and build collective strategies of economic growth.

In this context, Brazilian credit cooperatives configure themselves as instruments of territorial governance, by combining democratic management, community proximity and local reinvestment, elements that contribute to the strengthening of social and economic cohesion. This evidence demonstrates that the classical theories initially cited remain pertinent for interpreting Brazilian regional inequalities, especially when articulated with contemporary approaches of social capital and endogenous development (Putnam, 1993; Vázquez Barquero, 2002).

This theoretical basis guides the understanding of how cooperativism, especially credit cooperativism, operates in distinct socio-economic contexts, enhancing local dynamics of inclusive and sustainable growth. The main theoretical contributions that underpin the analysis of regional development and its relationship with credit cooperativism can be synthesised in Chart 1.

Table 1

Main theoretical approaches to regional development

Author	Theoretical contribution	Relationship with the study
Perroux (1950)	Growth poles theory	Explains the spatial concentration of economic activities
Myrdal (1957)	Circular cumulative causation	Highlights the reinforcement of regional inequalities
Hirschman (1958)	Productive linkages	Shows how strategic sectors dynamise economies
Putnam (1993)	Social capital	Highlights the role of trust and cooperation
Vázquez Barquero (2002)	Endogenous territorial development	Emphasises the importance of local dynamics and resources

Source: prepared by the authors based on the literature.

From this theoretical framework, it becomes possible to understand the potential of cooperativism as an instrument for promoting regional development. In the Brazilian case, however, the expansion of credit cooperatives presents an uneven territorial distribution, concentrating mainly in the South and South-east regions, which highlights the need to analyse their activity and the challenges of consolidation in other regions of the country.

2.3 CREDIT COOPERATIVES AND REGIONAL INEQUALITIES IN BRAZIL

The literature shows that, in regions with lower banking density, such as part of the Brazilian North, credit cooperatives can play a strategic role in financial inclusion and in the strengthening of local economies (Porto, 2020).

In Brazil, the cooperative movement evolved unevenly across regions. The South presents a high density of cooperatives per municipality, a robust institutional structure and high volumes of assets and revenue, while the North is still expanding its presence, especially in the agricultural and credit branches (Manenti, 2021). This regional heterogeneity has frequently been highlighted by the literature as an important element for understanding the different impacts of credit cooperatives on the economic and social development of territories.

Although the presence of credit cooperatives is more consolidated in the South and South-east regions, experiences observed in states of the North region demonstrate the potential of these institutions to promote financial inclusion and to support local economic activities. In this sense, Porto (2002), in studying a rural credit cooperative in Rondônia, shows the importance of these organisations for the strengthening of regional economies.

Thus, the effects of cooperativism go beyond the financial sphere, by strengthening relationships of cooperation, social participation and territorial development. From this perspective, cooperatives can be understood not only as financial organisations, but also as

institutions capable of promoting inclusion and local development (Singer, 2002; Oliveira, 2013).

Against this background, the presence of credit cooperatives may represent a relevant alternative for broadening access to financial services in regions historically less served by the traditional banking system. In this sense, these institutions can contribute to the mobilisation of local resources, the strengthening of productive activities and economic dynamisation in different territories.

The literature analysed shows that the territorial distribution of credit cooperatives in Brazil remains marked by significant regional inequalities. Although several studies point to the contributions of these institutions to financial inclusion and local economic development, a concentration of the research in regions where cooperativism is already more consolidated is observed. This finding reinforces the importance of systematic reviews capable of identifying patterns, convergences and gaps in the scientific output on credit cooperativism and regional development.

The set of theoretical contributions presented makes it possible to understand credit cooperativism as a potential agent of financial inclusion and of dynamisation of local economies. On the basis of this theoretical framework, the next section describes the methodological procedures adopted in conducting the systematic literature review.

3 RESEARCH METHOD

This research is characterised as a systematic literature review, conducted with the aim of identifying, selecting and analysing scientific studies related to credit cooperativism and regional development. The review was structured on the basis of the recommendations of Snyder (2019) and the guidelines of the PRISMA protocol, seeking to ensure transparency, methodological rigour and traceability of the study-selection process.

The search was carried out in the Web of Science, Scopus, SciELO and SPELL databases, selected for their relevance in indexing national and international studies in the areas of Administration, Economics and Regional Development. To retrieve the works, combinations of descriptors related to credit cooperativism and regional development were used, employing Boolean operators (*AND* and *OR*). Among the combinations used, expressions such as “credit cooperatives” *AND* “regional development” stand out, as well as variations involving the terms “credit cooperativism”, “local development”, “credit cooperatives” and “regional development”.

The following inclusion criteria were adopted: (i) scientific articles published in peer-reviewed journals; (ii) studies related to credit cooperativism and regional development; (iii)

publications in the period from 2015 to 2025; and (iv) availability of the full text. As exclusion criteria, duplicate works, studies without adherence to the theme and publications outside the scope of the research were considered. In order to make the protocol adopted in the systematic review more transparent, Chart 2 presents a synthesis of the main methodological stages of the research.

Table 2

Systematic review protocol

Stage	Procedure adopted
Research question	How has scientific output addressed the relationship between credit cooperativism and regional development?
Databases consulted	Web of Science, Scopus, SciELO and Spell
Period analysed	2015–2025
Inclusion criteria	Peer-reviewed articles, relevant to the theme and available in full
Exclusion criteria	Duplicates, out of scope or without thematic relevance
Studies identified	59
Studies after screening	53
Final studies analysed	15
Analysis technique	Thematic synthesis

Source: prepared by the authors based on the literature.

As presented in Chart 2, the review was conducted on the basis of previously defined criteria, covering the selection of the databases, the inclusion and exclusion criteria, as well as the procedures for analysing the studies. The adoption of this protocol sought to ensure greater methodological consistency and transparency in the literature-selection process.

The selection process took place in successive stages. Initially, the titles and abstracts of the studies retrieved from the databases were analysed. Subsequently, the works potentially adhering to the research objective were submitted to full reading in order to verify eligibility. Studies that did not directly address the relationship between credit cooperativism and regional development were excluded, as were works focused on other segments of cooperativism or on non-cooperative financial institutions.

The search resulted in 59 articles, distributed across the Web of Science (9), Scopus (5), SciELO (5) and SPELL (40) databases. After the removal of duplicates, 53 records remained, which were submitted to screening by title and abstract. Of these, 38 were excluded for not meeting the eligibility criteria. In the end, 15 studies were selected for full reading and included in the final analysis. No additional exclusions were identified at the full-reading stage. The final studies constituted the analytical corpus of the present systematic review.

Data analysis was carried out by means of thematic synthesis, a technique widely used in systematic reviews to identify recurrent patterns in the literature. Initially, the selected studies were read in full and analysed with regard to their objectives, methods and main results. Next, the findings were grouped according to their thematic proximity, allowing the construction of emerging analytical categories. This process resulted in the definition of three central axes of analysis: (i) credit cooperativism and financial inclusion; (ii) cooperativism and regional development; and (iii) gaps and challenges in the literature on credit cooperativism and regional development. The categorisation was carried out inductively, on the basis of the recurrent themes identified in the selected studies.

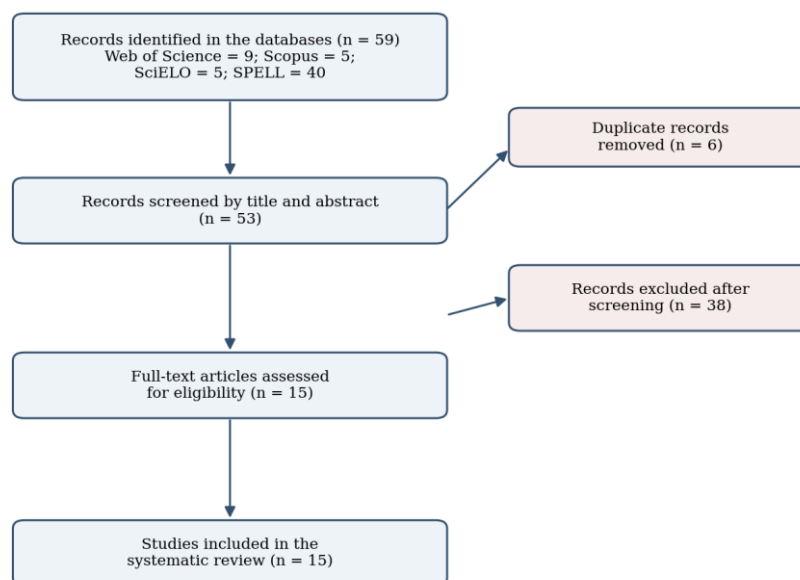
For the purposes of data extraction and organisation, information was recorded relating to the authors, year of publication, geographical context analysed, methodological approach and main results of the selected studies. This information supported the construction of the synthesis charts and the identification of the thematic patterns discussed in the results section.

The adoption of a systematic strategy for searching and selecting the studies aims to ensure greater methodological rigour, transparency and reproducibility of the research, reducing biases in the selection of the literature. In addition, the use of analytical categories contributed to the organisation and interpretation of the results, favouring a more structured understanding of the scientific output on the subject.

The study-selection process followed the guidelines of the PRISMA protocol, as illustrated in Figure 1.

Figure 1

Study selection flow according to the PRISMA protocol



Source: prepared by the author (2025).

It is worth noting that, although the total number of studies identified is not high, greater thematic adherence was observed in the additional databases, which contributed to the increase in the number of studies eligible for analysis.

4 ANALYSIS OF RESULTS

The analysis of the literature made it possible to identify different approaches to the role of credit cooperativism in regional development. Of the studies initially identified, some were excluded for not presenting direct adherence to the research object, such as works focused on other sectors or that addressed the banking system in general, without a specific focus on credit cooperatives.

From the selected studies, it is observed that the literature on credit cooperatives and regional development presents a predominance of empirical approaches, with different geographical and methodological scopes. In general, there is convergence regarding the contribution of these institutions to financial inclusion, local economic dynamisation and the strengthening of regional development, although the results are not uniform across all the contexts analysed.

On the basis of the thematic synthesis of the selected studies, the results were organised into three analytical axes: (i) credit cooperativism and financial inclusion; (ii)

cooperativism and regional development; and (iii) gaps and challenges in the literature on credit cooperativism and regional development.

4.1 CREDIT COOPERATIVISM AND FINANCIAL INCLUSION

With regard to financial inclusion, the literature shows that credit cooperatives play a relevant role in broadening access to financial services, especially in regions characterised by a lesser presence of the traditional banking system. Unlike conventional financial institutions, cooperatives operate on the basis of principles of proximity, mutualism and member participation, which favours the provision of financial services adapted to local needs (Barros et al., 2020).

In this context, the activity of credit cooperatives contributes to the reduction of market failures associated with financial exclusion, particularly in serving small producers, micro-entrepreneurs and lower-income populations, segments frequently neglected by traditional banking institutions. As Singer (2002) and Vázquez Barquero (2002) point out, economic organisation based on collective and territorially rooted structures tends to promote greater financial inclusion in territorially specific contexts.

The studies analysed converge in indicating that financial inclusion constitutes one of the main mechanisms through which credit cooperatives contribute to regional development. In different contexts, the results indicate that these institutions broaden access to credit and financial services for groups traditionally excluded from the conventional financial system, especially small rural producers, micro-entrepreneurs and populations located in smaller municipalities.

In the Brazilian case, data from the Central Bank of Brazil (BCB, 2024) indicate that credit cooperatives are present in approximately 55% of municipalities, which shows their high territorial capillarity. This presence is particularly relevant in localities underserved by traditional banks, reinforcing their role as an instrument of financial inclusion in peripheral regions with lesser access to formal financial services.

Convergence between the studies is also observed regarding the positive effects of the presence of cooperatives on financial inclusion. However, the research differs as to the explanatory mechanisms of these results. While some authors emphasise territorial proximity and knowledge of local realities, others highlight aspects related to cooperative governance, member participation and the capacity of cooperatives to adapt their services to the specific demands of the communities served.

In this way, the literature converges in pointing out that credit cooperativism acts as a relevant mechanism of financial inclusion, but also of the broadening of access to financial

services in a more equitable manner among different social groups. This activity proves particularly relevant in contexts characterised by a lesser supply of formal financial services, in which cooperatives can contribute to broadening access to credit and to strengthening processes of local and regional development.

4.2 COOPERATIVISM AND REGIONAL DEVELOPMENT

In the field of regional development, credit cooperatives are frequently associated with processes of local economic dynamisation. The literature points out that these organisations act as instruments for strengthening regional economies, by promoting the circulation of resources within the communities themselves (Singer, 2002; Vázquez Barquero, 2002; Barros et al., 2020).

Although the literature recognises the potential of credit cooperatives to drive regional development, the results observed vary according to the economic, institutional and territorial contexts analysed. In general, the studies identify positive effects related to income generation, job creation, the strengthening of local productive activities and the broadening of financial inclusion. Chart 3 presents a synthesis of the main studies identified in the systematic review.

Table 3

Synthesis of the studies on credit cooperatives and regional development

Author/Year	Main results
Queiroz et al. (2022)	Low scientific output and concentration of authors
Cavinato; Capitani (2023)	Credit cooperatives show greater impact in less developed regions
Jacques; Oliveira (2016)	The presence of cooperatives is associated with increased income in municipalities
Schuntzemberger et al. (2015)	The presence of cooperatives is associated with improved local economic indicators
Silva Filho; Silva (2025)	Expansion of cooperatives associated with increased credit, income generation and local development
Souza et al. (2023)	Cooperatives promote financial inclusion and income generation
Rovani et al. (2020)	Cooperatives contribute to job creation
Greatti; Sela (2021)	Cooperatives broaden financial inclusion and act as instruments of local development

Source: prepared by the author based on the analysed literature (2025).

The analysis of the studies synthesised in Chart 3 reveals a predominance of evidence favourable to the contribution of credit cooperatives to regional development. The most recurrent results relate to the broadening of access to credit, income generation, the strengthening of local productive activities, financial inclusion and the economic dynamisation

of territories. It is also observed that the identified impacts tend to be more pronounced in contexts characterised by lower economic development or a lesser presence of the traditional financial system, reinforcing the potential of cooperatives as instruments of local development.

In the Brazilian context, the studies of Jacques and Oliveira (2016), Schuntzemberger et al. (2015), Souza et al. (2023), Rovani et al. (2020), Greatti and Sela (2021) and Silva Filho and Silva (2025) point to convergent results regarding the contribution of cooperatives to regional development. The evidence found associates the presence of these institutions with increased municipal income, job creation, the broadening of the supply of credit and the strengthening of local economies.

Similar results are also observed in international studies. Research carried out in Spain (Alcaraz et al., 2021a; Alcaraz et al., 2021b; Giagnocavo, 2020) identifies contributions of cooperatives to territorial development and to the strengthening of local economies. In Italy, Agostino et al. (2022) and Aiello and Bonanno (2016) verified positive relationships between credit cooperativism, regional economic dynamics and business creation. Similarly, Moreno and Ávila (2021), in analysing Eurozone countries, observed that cooperatives contribute to the reduction of income inequalities and to the broadening of financial inclusion.

However, the effects of credit cooperatives on regional development are not consensual in the literature. Korzeb et al. (2019) identified contexts in which the presence of these institutions did not present a statistically significant relationship with certain local development indicators. These results suggest that the impacts of cooperativism depend on the specific characteristics of the territories analysed, as well as on institutional, economic and social factors that condition their activity.

In addition to the empirical evidence identified, the literature presents important limitations. As observed by Queiroz, Flach and Mattos (2022), the scientific output on credit cooperativism and regional development is still characterised by relative thematic dispersion and concentration of authors. Additionally, a geographical concentration of the research in European countries and in Brazilian regions where cooperativism presents a greater degree of institutional consolidation is observed. Such a characteristic shows the need to broaden studies in less explored contexts, as well as to develop methodological approaches capable of more robustly assessing the impacts of cooperatives on regional development indicators.

4.3 GAPS AND CHALLENGES IN THE LITERATURE ON CREDIT COOPERATIVISM AND REGIONAL DEVELOPMENT

The analysis of the selected studies made it possible to identify important gaps in the literature on credit cooperativism and regional development. Although the results point, in general, to positive contributions of cooperatives to financial inclusion, the strengthening of local economies and the dynamisation of productive activities, a thematic and geographical concentration of the research in specific contexts is observed, limiting the generalisation of the results.

One of the main gaps identified relates to the regional distribution of the studies. Most of the research concentrates in regions where credit cooperativism presents a greater degree of institutional consolidation, especially in the South and South-east regions of Brazil and in European countries. In contrast, regions such as the North and North-east remain relatively underexplored by the literature, despite presenting characteristics that make the investigation of the role of cooperatives in promoting financial inclusion and regional development particularly relevant.

These findings are consistent with empirical evidence from the literature, which points to the role of credit cooperatives in promoting regional development, especially in less favoured contexts. Studies indicate that these institutions have a greater impact in less developed regions, contributing to the reduction of territorial inequalities (Cavinato; Capitani, 2023). In addition, there is evidence of positive effects on local economic indicators, such as the income of Brazilian municipalities, reinforcing their activity as inducers of regional economic development (Jacques; Oliveira, 2016). In line with these results, analyses with a quasi-experimental approach also identify a positive impact of the presence of cooperatives on the agricultural GDP per capita, showing their contribution to local economic growth (Schuntzenberger et al., 2015).

This regional inequality can be understood in the light of structural factors, such as lower banking density, logistical difficulties, population dispersion and a lower level of productive organisation in regions such as the North. In this context, the lesser presence of credit cooperatives not only reflects these limitations, but also contributes to the maintenance of restrictions on access to formal financial services.

On the other hand, this scenario shows the strategic potential of credit cooperativism as a mechanism for promoting regional development. In regions less served by the traditional financial system, the expansion of these institutions can contribute to broadening access to credit, fostering local productive activities and strengthening regional economies, especially in contexts of greater economic vulnerability (Barros *et al.*, 2020).

Thus, the analysis of the literature shows important knowledge gaps regarding credit cooperativism and regional development, reinforcing the need to broaden research in less explored regions and to use more robust methodological approaches.

5 FINAL CONSIDERATIONS

This study aimed to analyse how scientific output has addressed the relationship between credit cooperativism and regional development, by means of a systematic literature review. The analysis of the selected studies made it possible to identify the main themes investigated, the predominant methodological approaches, the results found and the gaps present in the scientific output on the subject.

The literature analysed highlights that credit cooperatives play a relevant role in broadening access to credit, in the mobilisation of local resources and in the strengthening of regional economies. By operating on the basis of principles of cooperation, democratic participation and community reinvestment, these organisations contribute to the generation of social capital and to the promotion of more inclusive economic dynamics.

The review showed that the literature tends to associate credit cooperatives with positive effects on financial inclusion, local economic dynamisation and the strengthening of regional economies. However, the results are not homogeneous, since some studies point out that the impacts of these institutions depend on specific institutional, economic and territorial factors.

As limitations of this study, the fact that the analysis was based exclusively on a literature review stands out, not covering the empirical analysis of economic or performance indicators of cooperatives in the different regions of the country. In this sense, future research may broaden the use of quantitative methods, comparative analyses between regions and longitudinal studies capable of deepening the understanding of the impacts of credit cooperatives on regional development.

By systematising the literature on credit cooperativism and regional development, this study contributes to highlighting the relevance of these institutions in promoting financial inclusion and in reducing territorial inequalities in the Brazilian context.

Finally, it is hoped that this study contributes to the advancement of academic discussions on credit cooperativism and regional development, offering a systematised view of the existing scientific output and identifying opportunities for the development of new research agendas. By highlighting convergences, divergences and gaps in the literature, the research provides input for future investigations and for the improvement of the debate on the role of credit cooperatives in the economic and social development of territories.

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DIGITAL INCLUSION POINTS IN THE BRAZILIAN STATE COURTS
PONTOS DE INCLUSÃO DIGITAL NA JUSTIÇA COMUM ESTADUAL
BRASILEIRA

PUNTOS DE INCLUSIÓN DIGITAL EN LA JUSTICIA COMÚN ESTADUAL
BRASILEÑA

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ABSTRACT

Considering that the digitalization of the Brazilian Judiciary turns participation in digital environments into a requirement for engaging with the legal system and makes digital inclusion a constitutive dimension of the right of access to justice, this study aims to analyze the national landscape of implementation of the Digital Inclusion Points in the state Courts of Justice, considering their normative foundations, institutional structure and territorial distribution. To this end, a qualitative, descriptive-analytical approach is adopted, based on documentary analysis of normative acts, ordinances, resolutions, institutional programmes and data from the Courts of Justice and the National Council of Justice. Thus, a marked heterogeneity in implementation is observed, with courts at different stages of institutionalization and territorial reach, a variation that stems less from economic factors and more from institutional arrangements, organizational strategies and degrees of policy prioritization. This allows the conclusion that the Digital Inclusion Points may either reduce or reproduce structural inequalities in access to digital justice, so that their effectiveness depends on the articulation between infrastructure, technical support and territorial reach, rather than on normative provision alone.

Keywords: Access to Justice. Digital Inclusion. Digital Justice. Judiciary. Public Policy.

RESUMO

Considerando que a digitalização do Poder Judiciário brasileiro transforma a inserção em ambientes digitais em requisito de participação no sistema jurídico e faz da inclusão digital uma dimensão constitutiva do direito de acesso à justiça, objetiva-se analisar o cenário nacional de implementação dos Pontos de Inclusão Digital nos Tribunais de Justiça estaduais, considerando seus fundamentos normativos, sua estrutura institucional e sua distribuição territorial. Para tanto, procede-se à abordagem qualitativa, de caráter descritivo-analítico, com análise documental de atos normativos, portarias, resoluções, programas institucionais e dados dos Tribunais de Justiça e do Conselho Nacional de Justiça. Desse modo, observa-se acentuada heterogeneidade na implementação, com tribunais em diferentes estágios de institucionalização e capilaridade, variação que decorre menos de

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fatores econômicos e mais de arranjos institucionais, estratégias organizacionais e graus de priorização da política. Isso permite concluir que os Pontos de Inclusão Digital podem tanto reduzir quanto reproduzir desigualdades estruturais no acesso à justiça digital, de modo que sua efetividade depende da articulação entre infraestrutura, suporte técnico e inserção territorial, e não apenas de sua previsão normativa.

Palavras-chave: Acesso à Justiça. Inclusão Digital. Justiça Digital. Poder Judiciário. Políticas Públicas.

RESUMEN

Considerando que la digitalización del Poder Judicial brasileño convierte la inserción en entornos digitales en un requisito de participación en el sistema jurídico y hace de la inclusión digital una dimensión constitutiva del derecho de acceso a la justicia, se objetiva analizar el escenario nacional de implementación de los Puntos de Inclusión Digital en los Tribunales de Justicia estaduais, considerando sus fundamentos normativos, su estructura institucional y su distribución territorial. Para ello, se procede a un enfoque cualitativo, de carácter descriptivo-analítico, con análisis documental de actos normativos, ordenanzas, resoluciones, programas institucionales y datos de los Tribunales de Justicia y del Consejo Nacional de Justicia. De esta manera, se observa una acentuada heterogeneidad en la implementación, con tribunales en diferentes etapas de institucionalización y capilaridad, variación que deriva menos de factores económicos y más de arreglos institucionales, estrategias organizativas y grados de priorización de la política. Esto permite concluir que los Puntos de Inclusión Digital pueden tanto reducir como reproducir desigualdades estructurales en el acceso a la justicia digital, de modo que su efectividad depende de la articulación entre infraestructura, soporte técnico e inserción territorial, y no solo de su previsión normativa.

Palabras clave: Acceso a La Justicia. Inclusión Digital. Justicia Digital. Poder Judicial. Políticas Públicas.

1 INTRODUCTION

The digitalization of the Brazilian Judiciary constitutes one of the most significant processes of institutional transformation of recent decades, by shifting the provision of justice into digital environments and redefining the conditions of access and participation. In the legal field, this movement materializes in the consolidation of a model of digital justice, structured on the basis of normative frameworks such as Lei nº 11.419/2006 and institutional policies conducted by the Conselho Nacional de Justiça (CNJ), which guide the digitalization of judicial services in the name of efficiency, celerity and the broadening of access.

However, the digitalization of the Judiciary does not take place within a homogeneous social context. The incorporation of technologies as compulsory mediation for access to justice introduces new requirements of participation, related to the availability of technological infrastructure and the mastery of digital practices. In a country marked by structural inequalities in access to the internet and to electronic devices, this process tends to produce contradictory effects, expanding institutional capacity while at the same time restricting access for certain social groups.

The literature on access to justice allows this tension to be understood. Cappelletti and Garth (1988) demonstrate that effective access to rights depends on overcoming economic, social and cultural barriers. In the contemporary context, these barriers also assume a technological dimension, insofar as access to the justice system comes to depend on insertion into digital environments. Digital exclusion, in this scenario, emerges as a specific form of legal exclusion, compromising material equality between subjects.

In this context, digital inclusion becomes a central legal problem, since it conditions the exercise of fundamental rights. Digitalization, by becoming necessary mediation, redefines the criteria of access to jurisdiction, requiring the formulation of public policies capable of confronting the inequalities that pervade access to technologies. The absence of such policies tends to produce a more efficient system for those who already have access, while at the same time excluding those who do not have the necessary conditions to participate.

It is in this scenario that the Digital Inclusion Points are situated, instituted by Resolução nº 508/2023 of the CNJ (Conselho Nacional de Justiça, 2023) as a strategy aimed at mediating inequalities in access to digital justice. These spaces seek to guarantee minimum material conditions for participation in the judicial system, through the provision of technological infrastructure and technical support. The creation of the Digital Inclusion Points therefore represents an institutional response to the contradictions produced by the digitalization process.

From this context, the present article is guided by the following research question: how is the Brazilian landscape of implementation of the Digital Inclusion Points in the Courts of Justice configured, and what are its implications for access to justice in a context of digital inequality? This question makes it possible to articulate the empirical analysis of the public policy with the theoretical reflection on the conditions of access to the justice system in the digital environment.

The general objective of the article is to analyze the national landscape of implementation of the Digital Inclusion Points in the state Courts of Justice, considering their normative foundations, institutional structure and territorial distribution. Specifically, it seeks to understand, on the basis of empirical data, how the policy is operationalized across the Brazilian territory, identifying its advances, limits and inequalities. The premise is that the variation observed between courts stems less from structural variables, such as economic capacity or regional development, and more from different institutional arrangements, organizational strategies and degrees of policy prioritization within each judicial structure.

The text is organized into sections that articulate the theoretical framework, the methodology, the results and the discussion. Initially, the digitalization of the Judiciary and the emergence of digital inclusion as a legal problem are discussed, situating the debate within the theoretical field, as well as the Digital Inclusion Points as a public policy. Subsequently, the methodological path is described. Finally, the national overview of the implementation of the policy is presented, based on empirical data from the Courts of Justice, followed by the concluding remarks.

2 THEORETICAL FRAMEWORK

The digitalization of the Brazilian Judiciary is part of a broader process of restructuring the forms of State action, in which the incorporation of information and communication technologies redefines the modes of providing justice. In the legal field, this transformation shifts practices historically anchored in physical presence into environments mediated by digital platforms, altering the materiality of access to justice. This shift operates not only at the technical level, but redefines the concrete conditions of participation in the judicial system, introducing new requirements for the exercise of rights.

2.1 THE DIGITALIZATION OF THE JUDICIARY AND DIGITAL INCLUSION AS A LEGAL PROBLEM

The digitalization of the Judiciary is part of the logic of the network society, in which connectivity comes to condition the participation of subjects in different institutional spheres

(Castells, 1999). In this context, digital technology must be understood as a sociotechnical system, since it articulates infrastructure, devices and social practices, producing access filters related to connection, the mastery of digital interfaces and the availability of equipment (Lemos, 2013). In the justice system, this means that technology does not act as a neutral instrument, but as mediation that can broaden or restrict the effective exercise of the right of access to justice.

In Brazil, this process is institutionally driven by normative frameworks aimed at the modernization of justice and the overcoming of procedural slowness. Lei nº 11.419/2006 institutes the electronic judicial process, profoundly altering the dynamics of procedural processing (Brasil, 2006). This movement is intensified by CNJ policies, such as the Programa Justiça 4.0, articulated with Resolução nº 345/2020, which combines digitalization, automation and the broadening of remote access to judicial services (Conselho Nacional de Justiça, 2020).

These initiatives are part of an administrative rationality guided by the principle of efficiency, incorporated into the constitutional text by Emenda nº 19/1998. According to Di Pietro (2017), efficiency implies the optimization of resources and the improvement of the provision of public services. In the Judiciary, this logic materializes in the reduction of operational costs, the acceleration of processes and the broadening of remote service. However, this rationality tends to prioritize institutional performance without necessarily considering the social conditions of access of the population.

The intensification of digitalization during the Covid-19 pandemic makes this movement evident. The virtualization of hearings, remote service and digital processing came to constitute the dominant standard of functioning of the Judiciary. According to Saldanha and Medeiros (2018), the consolidation of an electronic process model exposes the dependence on material conditions of access, especially with regard to the exclusion of subjects who do not have the technological conditions necessary to participate in this model. The same authors demonstrate that access to justice depends on concrete material conditions, which, in the digital environment, include connectivity, equipment and specific competences, so that the absence of these conditions transforms technology into an obstacle, rather than a means of access.

This condition is particularly relevant in a country marked by structural inequalities in access to technology. Data from the TIC Domicílios 2024 survey indicate that the internet is present in all households of class A, but in about two-thirds of the homes of classes D and E, and that approximately 29 million people still do not use the internet in the country, of whom the majority have schooling up to primary education and a significant portion declare

themselves to be Black or Brown (Núcleo de Informação e Coordenação do Ponto BR, 2024). Peripheral regions, rural areas and populations in situations of vulnerability present significantly lower levels of access and connection quality, which limits their insertion into the digital justice system.

The literature on access to justice allows this displacement of barriers to be understood. Cappelletti and Garth (1988) identify that access involves overcoming economic and social obstacles; in the contemporary context, these obstacles also assume a technological dimension. Digital exclusion comes to operate as a specific form of legal exclusion, insofar as it impedes the effective exercise of formally guaranteed rights. In this sense, as Sadek (2010) observes, the justice system must be evaluated not only by the quantitative broadening of demands, but by the effective quality of access, which, in the digital field, implies recognizing that jurisdiction depends on the insertion of subjects into technological environments.

The digitalization of the Judiciary, therefore, cannot be analyzed merely as technological advancement, but as a process that reconfigures power relations in access to justice. According to Santos (2007), the justice system constitutes a space of dispute, in which different forms of exclusion are manifested. In the digital context, these exclusions are reorganized on the basis of the unequal distribution of access to technology, making it evident that institutional modernization can coexist with the reproduction of inequalities. The absence of structured policies of digital inclusion tends to deepen this scenario, insofar as digitalization advances without the corresponding guarantee of material conditions of access.

2.2 THE DIGITAL INCLUSION POINTS AS A PUBLIC POLICY

It is in this context that the Digital Inclusion Points are configured as a public policy institutionalized within the scope of the Judiciary. Resolução nº 508/2023 of the CNJ provides that it is incumbent upon the courts to install such spaces, to the extent of their availability and through joint actions between the branches of Justice, recognizing that digitalization requires compensatory mechanisms capable of guaranteeing access for populations in situations of digital vulnerability (Conselho Nacional de Justiça, 2023). The Digital Inclusion Points do not emerge as an isolated initiative, but as an improvement of Recomendação nº 130/2022 (Conselho Nacional de Justiça, 2022) and as a normative response to a structural contradiction between technological modernization and social inequality.

The Digital Inclusion Points constitute physical spaces equipped with technological infrastructure, in which the State provides equipment, internet connection and technical support to enable access to judicial services. These spaces may be installed in courthouses,

administrative units, municipalities, universities or in partnerships with public and private institutions, which broadens their territorial reach, with priority for municipalities that are not the seat of a judicial district or of a physical unit of the Judiciary. The policy is organized, therefore, on the basis of a logic of operational decentralization and institutional cooperation.

The function of the Digital Inclusion Points is not restricted to the provision of infrastructure. They operate as devices of sociotechnical mediation, in which the citizen is assisted in the use of digital judicial platforms. This mediation involves guidance for filing petitions, procedural consultation, participation in virtual hearings and service through the virtual counter. In this sense, they act in the translation between the digital system and the user, reducing the distance between institutional logic and the concrete conditions of the population. This is a policy guided by criteria of material inequality, which recognizes that formal access to justice does not, in itself, guarantee its effectiveness.

The operationalization of the Digital Inclusion Points involves articulation between different institutional actors. The Courts of Justice assume the coordination of the policy, while implementation may occur through partnerships with municipal entities, universities, public defenders' offices and other institutions. With regard to financing, the Digital Inclusion Points do not, as a rule, constitute a programme with a specific centralized budget, but are implemented from the courts' own resources, institutional agreements and the use of existing structures. This configuration reveals that the digital inclusion policy in the Judiciary is part of a complex federative arrangement, in which effectiveness depends on cooperation between different levels of government. The systematization of the policy is presented in Table 1.

Table 1

Systematization of the Digital Inclusion Points in the Brazilian Judiciary

Dimension	Characterization
Nature	Institutional public policy of the Judiciary
Normative basis	Resolução CNJ nº 508/2023 (improves Recomendação CNJ nº 130/2022)
Objective	Reduce inequalities in access to digital justice
Target audience	Populations in situations of digital vulnerability
Structure	Physical spaces with computers, internet and technical support
Operation	Mediation for access to digital judicial services and virtual counter
Implementation	Courts of Justice, with institutional partnerships
Financing	Own resources, agreements and existing structures
Organizational model	Variable according to the court
Scope	National, with unequal distribution

3 METHODOLOGY

The present study adopts a qualitative, descriptive-analytical approach, with a documentary analysis procedure. The choice of documentary research is justified by the institutional nature of the object investigated, which materializes in normative acts, administrative records and official data produced by the very bodies of the Judiciary. The research corpus is composed of normative acts, ordinances, resolutions, institutional programmes and data made available by the Courts of Justice and by the Conselho Nacional de Justiça.

The survey was carried out across the 26 state Courts of Justice and the Tribunal de Justiça do Distrito Federal e dos Territórios. The information was extracted from the institutional portals of the Courts of Justice, including transparency sections, normative acts, institutional news and administrative reports, as well as official documents related to the implementation of the Digital Inclusion Points. The analysis assumes a descriptive-analytical character, allowing the implementation of the policy to be mapped and its results to be interpreted in the light of the literature on access to justice and public policies (Souza, 2017; Arretche, 2012).

As an analytical procedure, the courts were classified into three categories, according to the degree of institutionalization identified: courts with effective implementation, evidenced by records of installed units and territorial reach; courts in the implementation phase, with a normative basis or institutional agreements, but without consolidated evidence of network functioning; and courts without identified formal institutionalization. It is recognized, as a limitation of the study, the dependence on the information made publicly available by the courts, which may underestimate ongoing initiatives not yet disclosed on their portals.

4 RESULTS AND DISCUSSION

The implementation of the Digital Inclusion Points within the scope of the Brazilian Courts of Justice reveals a scenario marked by institutional and territorial asymmetries, in which the public policy is not distributed homogeneously across the national territory. Although Resolução nº 508/2023 of the CNJ establishes the duty to create these spaces, their concrete materialization depends on the structural conditions of each court, which results in different levels of advancement in implementation. This pattern confirms what Souza (2017) identifies as a characteristic of public policies in federative contexts, in which decentralization tends to produce inequalities in execution.

In the group of courts with effectively implemented Digital Inclusion Points, consistent documentary evidence of functioning is identified, with records of installed units, territorial reach and, in some cases, quantitative data on expansion. Among these courts, the Tribunal de Justiça do Maranhão (TJMA) stands out, with 121 installed units; the Tribunal de Justiça de Mato Grosso (TJMT), with 60 units in operation; and the Tribunal de Justiça de Goiás (TJGO), with 47 implemented units. These data indicate an advanced level of institutionalization of the policy, associated with administrative capacity and the institutional prioritization of digital inclusion.

Still in this group, it is observed that the Tribunal de Justiça do Pará (TJPA) presents at least 62 publicly monitored units, while the Tribunal de Justiça da Paraíba (TJPB) records units in operation in 99 distinct municipalities, evidencing high territorial reach. The Tribunal de Justiça de Santa Catarina (TJSC), in turn, presents significant expansion, with 132 points identified in institutional records, which places it among the cases of greatest scope in the country. These data indicate that the policy, when articulated with territorial strategies, can reach expressive levels of coverage.

Other courts also present consolidated implementation, although with less quantitative detail, such as the Tribunais de Justiça da Bahia (TJBA), do Ceará (TJCE) and do Distrito Federal e dos Territórios (TJDFT), the latter with records of service in equipped courthouses. The Tribunal de Justiça de Pernambuco (TJPE) is part of the group with effective implementation, with a public list of classified units, while the Tribunal de Justiça do Piauí (TJPI) presents records of service provision on institutional panels. The Tribunal de Justiça do Rio Grande do Norte (TJRN) and the Tribunal de Justiça de Roraima (TJRR) likewise present evidence of functioning, although with specific institutional models.

On the other hand, a significant set of courts is in an intermediate stage, characterized by the existence of a normative basis or institutional agreements, but without consolidated evidence of network functioning. In this situation are the Tribunais de Justiça de Alagoas (TJAL), Amazonas (TJAM), Espírito Santo (TJES), Mato Grosso do Sul (TJMS), Paraná (TJPR), Rio de Janeiro (TJRJ), Rondônia (TJRO), São Paulo (TJSP) and Tocantins (TJTO). In these cases, the formal creation of the policy is observed, through ordinances, resolutions or cooperation agreements, but without public data that would allow the existence of Digital Inclusion Points in systematic functioning to be affirmed, which makes evident the difference between normative institutionalization and material execution of the policy.

The Tribunal de Justiça de São Paulo (TJSP), despite its institutional capacity, is in this category, with technical cooperation agreements signed, but without public consolidation of data on the functioning of the Digital Inclusion Points. This datum is particularly relevant,

as it indicates that administrative capacity does not automatically translate into effective implementation, reinforcing Arretche's (2012) argument on the complexity of implementing public policies in federative contexts. There are also situations of absence of identified formal institutionalization, as in the Tribunal de Justiça do Rio Grande do Sul (TJRS), in which no specific normative acts or documentary evidence of implementation were located in the period analyzed. The overview is synthesized in Table 2.

Table 2

National overview of the implementation of the Digital Inclusion Points

Category	Courts of Justice	Relevant data
Implemented (with evidence of functioning)	TJBA, TJCE, TJDF, TJGO, TJMA, TJMT, TJPA, TJPB, TJPE, TJPI, TJRN, TJRR, TJSC	Highlight: TJSC (132 DIPs), TJMA (121), TJPA (greater than or equal to 62), TJMT (60), TJGO (47), TJPB (99 municipalities)
Under implementation	TJAL, TJAM, TJES, TJMS, TJPR, TJRJ, TJRO, TJSP, TJTO	Existing normative basis or agreements, without consolidated network
Without identified institutionalization	TJRS	Absence of normative acts and of evidence of DIPs

Source: prepared by the author (2026).

The joint reading of these data makes evident that the digital inclusion policy in the Brazilian Judiciary cannot be explained only by differences in economic or structural capacity between the states. On the contrary, it is observed that courts inserted in distinct socioeconomic contexts present similar performances, while courts with high institutional capacity do not always present advanced levels of implementation. Courts located in states with lower economic capacity, such as Maranhão and Pará, present high levels of implementation and territorial reach, while courts situated in more structured contexts, such as São Paulo and Rio de Janeiro, are still in the initial stages of institutionalization of the policy.

This pattern indicates that the effectiveness of the policy is directly related to internal institutional factors, such as organizational strategies, administrative decisions and the degree of prioritization of the digital inclusion agenda within each court. The variation does not stem only from federative decentralization, but also from the way in which each court internalizes and operationalizes the policy. Moreover, the presence of more robust quantitative data is concentrated in the courts that developed mechanisms of monitoring and transparency, such as the monitoring panels adopted in Pará or the institutional programmes structured in Maranhão, which indicates that the production of data is also a central element for the consolidation of the policy.

From a theoretical point of view, this scenario confirms the analysis of Santos (2007), according to which universal public policies tend to produce unequal results when implemented in contexts marked by structural asymmetries. The digitalization of the Judiciary, by depending on technological infrastructure and institutional capacity, reproduces regional and institutional inequalities, even when guided by national norms. Thus, the national overview reveals not only the current stage of the policy, but also the structural limits that condition its effectiveness: the existence of courts with high territorial reach and others

without implementation makes evident that access to digital justice, in Brazil, remains pervaded by inequalities that require more robust policies of coordination and financing.

5 CONCLUSION

The analysis developed has made it possible to understand that the digitalization of the Brazilian Judiciary constitutes a structural process of reorganization of the forms of access to justice, in which technology comes to act as central mediation between the citizen and the legal system. This movement, driven by institutional policies aimed at efficiency and modernization, redefines the materiality of the exercise of rights, by shifting in-person practices into digital environments. However, this transformation does not take place in a neutral manner, since the incorporation of digital technologies occurs in a social context marked by profound inequalities in access to technological infrastructure.

Digital inclusion thus emerges as a constitutive dimension of the right of access to justice, insofar as it conditions the effective exercise of fundamental rights. Digital exclusion does not configure itself as a problem external to the legal system, but as an internal element of its operationalization. In this context, the Digital Inclusion Points configure themselves as an institutional response to the tension between technological modernization and social inequality, by providing infrastructure and technical support that reduce the barriers imposed by digitalization.

The empirical data demonstrate that the variation observed between the courts is not explained in a linear manner by economic or structural factors. Courts such as TJSC, TJMA, TJPA, TJMT and TJGO present more advanced levels of implementation, with an expressive quantity of Digital Inclusion Points and greater institutional integration, while courts such as TJSP, TJRJ, TJAM and TJPR are in an intermediate phase and the TJRS presents an absence of formal institutionalization. This scenario makes evident that the normative provision does not guarantee uniformity in the execution of the policy, whose effectiveness is directly related to institutional factors, such as the prioritization of the agenda, the capacity for inter-institutional articulation and the organizational models adopted.

In this way, the Digital Inclusion Points represent a relevant advance in the recognition of digital inclusion as a condition of access to justice, but their effectiveness depends on overcoming institutional asymmetries that pervade the Brazilian judicial system. The consolidation of the policy requires not only its normative provision, but the articulation between organizational strategies, institutional investment and adaptation to territorial specificities. It is concluded that the digitalization of the Judiciary will only configure itself as an instrument of democratization of access to justice when it is accompanied by policies

capable of confronting, in a concrete manner, the inequalities that condition the exercise of rights in the digital environment, which is why digital inclusion must be understood as a central dimension of contemporary judicial policy.

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TRADE OPENNESS AND GROWTH IN SECTORAL LABOUR PRODUCTIVITY: AN APPROACH USING THE SYNTHETIC CONTROL METHOD

ABERTURA COMERCIAL E CRESCIMENTO DA PRODUTIVIDADE SETORIAL DO TRABALHO: UMA ABORDAGEM COM O MÉTODO DE CONTROLE SINTÉTICO

APERTURA COMERCIAL Y CRECIMIENTO DE LA PRODUCTIVIDAD LABORAL SETORIAL: UN ENFOQUE QUE UTILIZA EL MÉTODO DE CONTROL SINTÉTICO



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ABSTRACT

The literature on trade opening and economic and productivity growth is vast and has generally encountered mixed results. Several criticisms have been made of the traditional methods of investigation applied to this research agenda. Both traditional econometrics and case study approaches suffer from their own shortcomings. We employ the Synthetic Control Method in the study of sectoral labour productivity growth for two cases of opening to international markets: South Korea (1968) and Botswana (1979). We find that industrial sector labour productivity is quite responsive after the trade opening, with at least 4 years of much faster growth than the synthetic control for both South Korea and Botswana. A more modest rise occurs in the services sector. The agricultural sector did not appear to be affected by such an event. We therefore support previous research that found the industrial sector to be highly affected by trade opening.

Keywords: Trade Opening. Labour Productivity Growth. Synthetic Control Method.

RESUMO

A literatura sobre abertura comercial e crescimento econômico e da produtividade é vasta e tem geralmente encontrado resultados mistos. Várias críticas foram feitas acerca dos métodos tradicionais de investigação aplicados nessa agenda de pesquisa. Ambos a econometria tradicional e os estudos de caso sofrem com defeitos próprios. Nós empregamos o Método do Controle Sintético no estudo do crescimento da produtividade do trabalho setorial para dois casos de abertura ao comércio internacional: Coreia do Sul (1968) e Botsuana (1979). Nós encontramos que a produtividade do trabalho na indústria responde significativamente após a abertura comercial, com ao menos 4 anos de crescimento da produtividade mais veloz que a do controle sintético para ambos, Coreia do Sul e Botsuana. Um crescimento mais modesto ocorre no setor de serviços. O setor agrícola não aparenta ser afetado em tal evento. Nós, portanto, fornecemos suporte às pesquisas anteriores que encontraram um setor industrial fortemente afetado pela abertura comercial.

Palavras-chave: Abertura Comercial. Crescimento da Produtividade do Trabalho. Método do Controle Sintético.

RESUMEN

La literatura sobre liberalización comercial y crecimiento económico y de productividad es extensa y, en general, ha arrojado resultados mixtos. Se han formulado diversas críticas respecto a los métodos de investigación tradicionales aplicados a este tema. Tanto la econometría tradicional como los estudios de caso presentan limitaciones. Empleamos el Método de Control Sintético para estudiar el crecimiento de la productividad laboral sectorial en dos casos de liberalización del comercio internacional: Corea del Sur (1968) y Botsuana (1979). Observamos que la productividad laboral en la industria responde significativamente tras la liberalización comercial, con un crecimiento de la productividad al menos cuatro años superior al del control sintético tanto para Corea del Sur como para Botsuana. El crecimiento en el sector servicios es más moderado. El sector agrícola no parece verse afectado por este fenómeno. Por lo tanto, respaldamos investigaciones previas que encontraron un sector industrial fuertemente afectado por la liberalización comercial.

Palabras clave: Liberalización Comercial. Crecimiento de la Productividad Laboral. Método de Control Sintético.

1 INTRODUCTION

The literature on trade opening and economic growth is vast. Many articles have attempted to identify whether opening to international markets has any effect on economic growth. Although vast, the question of identifying the factors involved has received some attention in the literature. Rodriguez and Rodrik (2001) pointed out some caveats. The authors reviewed four influential articles on trade opening and economic growth in the 1990s and argued that, although the specialists were very willing to associate episodes of trade liberalisation with economic growth, their conclusions were not very robust. The fact that the literature has constantly altered the methods and the measures of trade opening suggests, for the authors, that, instead of strongly supporting the relationship, the literature seems to point to more doubts than certainties.

At that time, there were two ways of investigating the subject. Either the studies concentrated on analyses of large data panels, or they focused more on case studies, as suggested by Bhagwati and Srinivasan (2001). The two approaches presented their own limitations, the first presenting endogeneity problems (Rodriguez; Rodrik, 2001), while the second was subject to a lack of statistical rigour.

The Synthetic Control Approach is seen as a third path between panel data and case studies, combining both methods to generate a better assessment of the topic. The emergence of this particular method began with Abadie and Gardeazabal (2003) and Abadie, Diamond and Hainmuller (2010). Many studies have come to use this type of analysis since the development of the method. The literature on macroeconomics, in particular, has benefited greatly from this method, since it has made possible a test similar to an experiment in a context where the need for a larger database is more limited. The approach, in essence, addresses the questions raised by Srinivasan and Bhagwati (2001), but without the shortcomings from a statistical point of view.

Let us take as an example Billmeier and Nanicinni (2013), who used a synthetic control approach to explore the opening to international markets and the growth of GDP per capita. They selected 30 cases in which they could explore the treated countries that had undergone trade opening in comparison with a counterfactual synthetic control that did not open. They used the Sachs-Warner indicator of trade opening to account for the opening episodes and carried out two different estimations. One in which the control group was composed of all possible countries and another in which the estimation was made within the region of the treated country, to better control for the geographical and historical characteristics. The authors found that the opening was effective in increasing per capita income. It was more

effective in the decades of the 1960s, 70s and 80s, but not in the 1990s, when most of the opening cases occurred in Africa.

Similar to Billmeier and Nanicinni (2013), a small but growing literature using the synthetic control approach is emerging to better assess the results of political and non-political shocks. The original articles of Abadie and Gardeazabal (2003) and Abadie, Diamond and Hainmuller (2010) addressed the economic costs of terrorism in the Basque Country and of an anti-tobacco law in California. Adhikari et al. (2016) assessed labour market reforms in Europe during the 1990s. Abadie et al. (2014) assessed the economic impact of German reunification. Cavallo et al. (2013) explored supply shocks generated by natural disasters, which is also the focus of Barone and Mocetti (2014), who studied institutions and growth after a supply shock generated by two earthquakes. Nannicini and Riciutti (2010) applied the method to study the impact of autocratic transitions on real GDP per capita. Campos, Coriceli and Moretti (2014) studied the impact of the formation of the European Union on the GDP per capita of the member countries.

In this article, we propose to take advantage of the synthetic control method to extend the study of Billmeier and Nanicinni (2013). We use the trade opening classification of Wacziarg and Welsh (2008) to redo the analysis of Billmeier and Nanicinni (2013) in a more disaggregated manner. This means that we are more interested in the sectoral evolution of labour productivity growth. There are three channels through which productivity may increase, based on Muendler (2002). It may be that: (i) better imported machinery is now available; (ii) a competitive pressure effect forces firms to become more productive in order to survive; (iii) there is a change in firm-level employment, as inefficient firms are pushed out of the market by foreign competition and efficient ones absorb more labour as a consequence. Effects (ii) and (iii) are expected only in the tradable sectors of agriculture and industry. Services are subject only to effect (i).

The analysis cannot be extended to many case studies, as in Billmeier and Nanicinni (2013), due to data limitations. It is necessary to have a specific country subject to an episode of trade opening and a set of comparison countries to construct the synthetic control. Our sectoral data do not cover such a large sample, but they offer the opportunity to study two major successful episodes of trade opening, according to Billmeier and Nanicinni (2013), in two different regions of the globe: South Korea and Botswana. These two cases may provide information about the importance of labour productivity growth in each sector after an episode of trade opening, as well as about which channels may be in action, by visualising which sectors responded more to the treatment.

Most studies on liberalisation and sectoral productivity growth point to the existence of a positive relationship, mainly for the industrial sector, due to greater access to data (Muendler, 2002; Pavcnik, 2002; Tybout; Westbrook, 1995; Levinsohn, 1993), but some others did not find such an effect (Pack, 1988; Tybout; De Melo; Corbo, 1991; Bernard; Jones, 1996). As already mentioned, in this controversy lie the criticisms of the methods used in the literature, made by Pritchett (2000), Bhagwati and Srinivasan (2001) and Rodriguez and Rodrik (2001). We therefore proposed to try to answer this question using a more recent approach.

We are not aware of any article that uses the synthetic control method to investigate trade opening based on sectoral data. Thus, we hope to shed light on the growth of sectoral labour productivity in the context of a method that is not subject to endogeneity problems and that is also more robust than case studies, which are more prone to biased data selection. In this way, we are addressing the same methodological questions that Billmeier and Naniccini (2013) dealt with in their article, as well as those raised by Rodriguez and Rodrik (2001) and Bhagwati and Srinivasan (2001).

The article is structured as follows: the next section briefly reviews the existing literature on trade opening and GDP growth and/or productivity growth. Both the older literature, subject to the criticisms of Rodriguez and Rodrik (2001), and the new literature that adopted the synthetic control approach. The methodology section explains the data and the synthetic control approach. The results present our estimates and the discussions. Then, the final considerations.

2 LITERATURE REVIEW

In this section, we analyse some articles on trade opening and growth, or trade opening and productivity growth. Most of the review will address older articles on the topic, generally using non-quasi-experimental techniques.

We have already discussed the work of Billmeier and Naniccini (2013) in the introduction. A quite similar article would be that of Campos, Coricelli and Moretti (2014), who investigated the access to the European Union market of 12 countries and their subsequent GDP per capita using the synthetic control method. The countries were classified into core and peripheral countries for analytical purposes. Entry into the common area is analogous to trade liberalisation, since one of the main characteristics of this integration is the reduction of tariffs. However, entry into the Eurozone also represents a broader reform, since not only the transit of goods is affected, but also financial flows and the integration of the labour market increase. Therefore, the article must be interpreted in a broader way. The results for the core

showed lower growth rates than for the periphery, although neither situation was statistically significant, which means that other peripheral nations that did not adopt the euro also presented a similar GDP per capita afterwards.

Ben David (1993) was interested in the relationship between trade opening and economic convergence. To study this, the author focused on the 6 original members of the European Economic Community (EEC). Both trade theories, through factor equalisation mechanisms, and neoclassical growth theories, through technology transfer, suggest that economic growth and convergence would be generated by trade opening. The author found that the convergence of low-income countries in the EEC is related to the timing of the opening. This is especially true for the countries that entered the community later but did not fully adhere to the trade agreements. Only after they began to integrate did their economies seem to converge to the level of the older and more advanced members. It is interesting to note that this article is related to that of Campos, Coricelli and Moretti (2014). They differ because Ben David (1993) is focused on the European Community, which foreshadowed the creation of the European Union. Different statistical techniques were applied and the results were opposite. In one article, we cannot attribute the convergence to the central levels of development to entry into the common markets, and in the other, this is the precise conclusion. It may be that the different circumstance was important, but also that the study of Ben David (1993) suffered from the methodological problems already mentioned.

As for the sectoral studies, most concentrate on the industrial sector, due to the availability of data on the manufacturing sector. The following articles studied the channels through which liberalisation may have an effect.

Levinsohn (1993) was one of the first to test what Muendler (2002) later called the competitive impulse. Levinsohn (1993) called this the imports-as-market-discipline hypothesis. It is the idea that firms may become more competitive if they are more exposed to competition. The author uses data from firms in the Turkish manufacturing sector to estimate an industrial organisation model especially suited to test the hypothesis, after Turkey opened its markets in 1984. The results were positive and there seems to be a competitive stimulus after the trade opening.

Tybout and Westbrook (1995) took advantage of the Mexican trade opening in 1986 to study the Mexican manufacturing industry by sector. The authors separated the effects into several possibilities: (i) the scale effect present in economies of scale; (ii) the share effects, or the reallocation of workers from low to high productivity; (iii) the residual effects: this term refers to the other possible effects, which are difficult to disentangle. Learning by doing, externalities, technological innovation, etc. Their findings pointed to a lesser importance of

economies of scale and to the greater relevance of residual effects, the use of foreign inputs and the share effect of the transfer of labour to more productive firms. The share effects were also highlighted by Pavcnik (2002), in his study on Chilean manufacturing firms after the trade liberalisation in the 1970s. It was found that this channel had notable importance for productivity growth.

These works pointed to the existence of productivity growth in the industrial sector through several sources. Thus, it would be expected that we would find a positive effect for the industrial sector of South Korea and Botswana, if they were well planned. In addition, we relate these articles to our findings in the conclusion.

3 METHODOLOGY

3.1 EMPIRICAL STRATEGY

We compare the patterns over time in labour productivity of countries exposed to trade opening with those of a control group of unaffected countries. To construct a reliable control group, we adopt the synthetic control method for comparative case studies (Abadie; Gardeazabal, 2003; Abadie et al., 2010). This is the most suitable method for understanding the effects of an exogenous change in policy that affects some countries while leaving others unaltered (control). The idea is to estimate the causal effect of a treatment as the difference between the outcome observed in the treated areas and that observed for a weighted average of the controls. The weights minimise a penalty function that depends on the pre-intervention pattern of the outcome variable and of several of its predictors.

The method, as described in Abadie *et al.* (2010), may be better formalised as follows: There are $J + 1$ regions and let the first be the one affected by the change in policy (trade opening). Now, y_{it}^1 let it be the labour productivity in country i ($i = 1, \dots, J+1$) at that moment t ($t = 1, \dots, T$) the country receives the change of policy, and y_{it}^0 if the country is not exposed to the change of policy. Let T_0 be the number of periods before the trade opening ($1 \leq T_0 \leq T$). We are then assuming that there is no way the opening to trade policy change can have an effect before the event occurs, so that $Y_{it}^0 = Y_{it}^1$ for any country and at any moment $t < T_0$. Let $\alpha_t = y_{it}^1 - y_{it}^0$ be the effect of the trade opening at moment $t > T_0$. Then, the labour productivity observed in the affected country may be written as: $y_{it}^1 = y_{it}^0 + \alpha_t D_t$. It follows, therefore, that for $t > T_0$, $\alpha_t = y_{it}^1 - y_{it}^0$, but y_{it}^0 is not observed and needs to be estimated. Abadie *et al.* (2010) suggest estimating α_t with $\alpha_t = y_{it} - \sum_{j=2}^J w_j y_{jt}$ for $t > T_0$, where the weights w_j are chosen to minimise a given penalty function (given by the Mean Squared Prediction Error - MSPE) that depends on the pattern of labour productivity before the opening and on the values of some predictors of labour productivity before the opening.

3.2 DATA

As already mentioned, we will study the effects of trade opening on the growth rates of labour productivity in two important cases: South Korea and Botswana. In order to be able to use the Synthetic Control method, we need to choose these countries as the ones that will receive the treatment, in order to construct the synthetic control adequately. Essentially, we need to introduce the treatment into a country and generate a set of countries unaffected by it. This requirement limits our possibilities of assessment, since, for many countries that experienced the opening to international markets, we could not find enough countries to generate a suitable control set.

We use the definition of open economy of Sachs and Warner (1995), extended by Wacziarg and Welch (2008), in line with Billmeier and Naniccini (2013). A country is defined as closed if: (i) the average tariffs exceed 40%; (ii) the non-tariff barriers cover more than 40% of its imports; (iii) it has a socialist economic system; (iv) the black market premium on exchange rates exceeds 20%; (v) a large part of its exports is controlled by a state monopoly.

Let us take South Korea as an example. It opened its markets in 1968, according to the definition above. We need to construct a synthetic control using other closed countries as potential controls, so that both are closed before 1968, and South Korea opens after that, while the others remain closed. This requirement is what limits the number of cases we can study, since we can only follow a sufficiently large set of controls for the experiences of South Korea and Botswana. The control set is constructed by organising categories of countries with some similarity. Asia, Latin America, North Africa and the Middle East were chosen to function as the control set for the South Korean experience. It is not advisable to include advanced OECD economies or poor Sub-Saharan African countries, because they are at different levels of development, and the proximity of the treated unit and the control set helps to further improve the pre-treatment suitability. As for Botswana, we chose Sub-Saharan Africa, Latin America, North Africa and the Middle East. We did this because Botswana is today one of the most advanced African economies and was already in a decade of high growth when it opened (World Bank data), in addition to already being a democracy, while most of Africa lived under dictatorships. Furthermore, adding more countries to the control group also contributes to the pre-treatment suitability.

For South Korea, which opened its borders in 1968, we considered the following countries and their respective opening dates as the control country set, using Wacziarg and Welch (2008) as the measure of opening: Argentina (1991), Brazil (1991), Chile (1976), Colombia (1986), Costa Rica (1986), Mexico (1986), Peru (1991), Venezuela (1989), India (always closed), Morocco (1984) and Egypt (1995).

For Botswana, which opened its borders in 1979, we considered the countries of Latin America, North Africa and the Middle East listed above, in addition to Ghana (1985), Kenya (1993), Malawi (always closed), South Africa (1991) and Senegal (always closed).

Our outcome is labour productivity by sector. We define labour productivity as value added per employed person. The data come from the sectoral database of the Groningen Growth and Development Center - GGDC. We define the agricultural sector as the agricultural sector of the GGDC. Industry is defined as (Mining + Manufacturing) in the GGDC. And services are defined as the sum of public services, construction, trade, transport, business services and personal services in the GGDC. We exclude government services from the metric because their productivity is more difficult to measure and may be biased.

Our set of predictor variables includes: Investment (Gross Fixed Capital Formation), World Development Indicators (World Bank), Population Growth (World Bank) and Inflation (GDP Deflator). Our measure of Human Capital is the share of the population with completed secondary education, called "Secondary Education", available in the Barro Lee Project (interpolated data). In addition, we also include a measure of democracy/institutional quality, called "Polity", available in the Polity IV database (Polity2). We also calculate the share of each sector, called "AgriShare", "IndShare" and "SerShare", also using the GGDC data and our classification of agriculture, industry and services.

We chose these predictors because they appear in most growth regressions and synthetic control method approaches for the predictors of output measures, and they are the ones with broad support in the literature (Barro, 1991, Billmeier; Naniccini, 2013), Abadie; Gardeazabal, 2003), Barone; Mocetti, 2014).

The logic behind the inclusion of these variables is as follows: the investment rate and population growth affect labour productivity through the capital stock available per worker, according to the Solow Model (1956). More capital means that workers can become more productive, since both factors of production are complementary. The capital stock per worker increases with a higher investment rate and decreases with greater population growth, since the entry of more workers into the market means a lower capital/labour ratio. The inflation rate and the measure of democracy control for the level of development and institutional quality. The level of schooling measures a qualified workforce, capable of being more productive. And the shares control for the structural transformations (Barro, 1991). As we do not have access to sectoral data on the predictors, we use the measures for the whole economy as a proxy. We argue that the sectoral data on the predictors probably follow closely the data for the whole economy. Furthermore, given that our control group is composed of countries with similar levels of development, they probably use predictors of similar quality

for each sector. For example, if Brazil allocates a larger share of its qualified workforce to the industrial sector, South Korea, which had a similar level of development, probably allocates a closer share.

We tried to fit the specification with all the predictors initially. When the Mean Squared Prediction Error is not satisfactory, then we tried to fit the specification with fewer predictors. This is especially true for the agricultural sector of South Korea. In addition, we also applied the Hodrick-Prescott filter on the labour productivity growth in the agricultural sector of South Korea, to avoid excessive fluctuations and a worse fit. The filter was applied using the smoothing factor θ of 6.25, which is the appropriate one for annual data. We tried to apply the filter also for Botswana, since the errors were larger than for South Korea, but smoothing the series did not help to fit a better synthetic control, so we chose to keep the original data, even if the fluctuations were large.

Many studies use all the pre-treatment values of the outcome variable as a predictor. We incorporate in our work the relatively recent criticism of this procedure. Ferman et al. (2016) carried out Monte Carlo simulations on several popular specifications for the synthetic control. They found that the inclusion of all the pre-treatment values of the outcome variable performed particularly poorly in the simulations. Along the same lines, Kaul et al. (2018) showed that the use of all pre-treatment values causes the optimisation procedure to reflect only the outcome, making the predictors irrelevant, which is not advisable if the objective is a realistic control. The work of Billmeier and Naniccini (2013) is criticised for its approach.

To deal with this issue, we use only up to 3 years of the pre-treatment outcome in our specification, leaving greater room for the predictors. The periods chosen for the analysis are 1964-1978 for South Korea and 1971-1989 for Botswana. We report a post-treatment effect of 10 years for both cases, but we concentrate more on the first 5 years, since it is more reasonable to identify such effects as related to the trade opening. The pre-treatment years are defined by the availability of data.

The graphs for the estimation of the synthetic control and the placebo are inserted directly into the text. It is worth noting that the balance of the predictors does not need to be entirely similar to the treated values. An attempt to fit one of the values will inevitably distort the others. What is important is to show a low Mean Squared Prediction Error for the pre-treatment years of the treated variable, as well as for the controls in the placebo experiments. The technique will always choose a combination that is more suitable than the weighted average of the values of all countries in the control set. Therefore, we do not report this characteristic.

4 RESULTS

In this section, we present the results. Firstly, we show the results for South Korea, broken down by sectors. The same occurs with Botswana. The tables with the unit weights and the balance of the predictors can be found in the appendix, as already mentioned. The graphs are presented in the text.

4.1 SOUTH KOREA

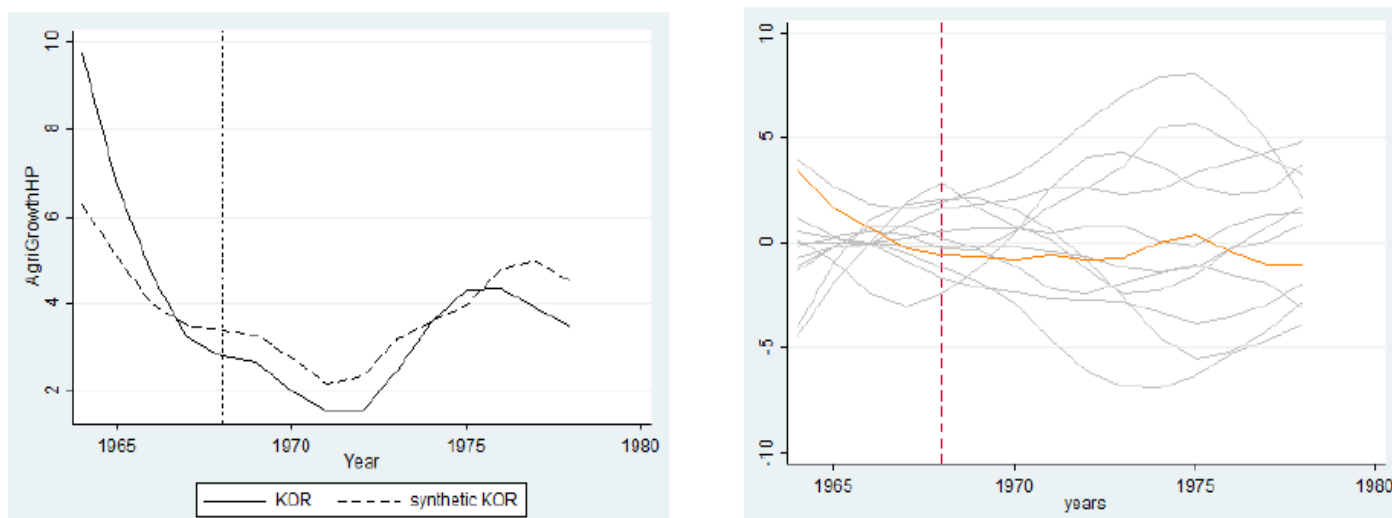
4.1.1 Agriculture

Firstly, we examine the results for the growth of labour productivity in the agricultural sector of South Korea. As already discussed, the synthetic control method uses a set of control countries to apply a minimisation algorithm and find the best pre-treatment fit of the real trajectory. We chose to select one of the intermediate years (1966), as it generated the best Mean Squared Error. In addition, we used the Hodrick-Prescott filter on the outcome variable to follow the trend and prevent the oscillation of the labour productivity growth rates from producing an inadequate fit. As mentioned in the data section, we use 6.25 as the smoothing factor, which is common in the literature for annual data.

We can observe the visual inspection presented in Figure 1(a). The fit does not seem very good for the first years, since the pattern of very high growth rates that fell rapidly is exclusive to the treated unit, but it follows a closer trend when near the treatment, in 1968. After the trade liberalisation, we could expect that the opening of the markets would produce an increase in the growth of labour productivity through the channels discussed. In fact, the trade opening does not seem to have affected the growth of labour productivity in the agricultural sector of South Korea in the post-treatment years, which is corroborated by the placebo estimates, whose results are presented in Figure 1(b) and show no signs of statistically significant effects.

Figure 1

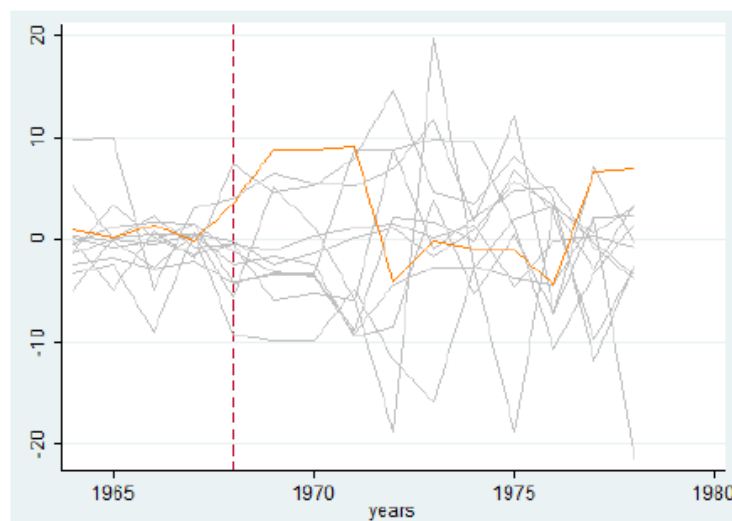
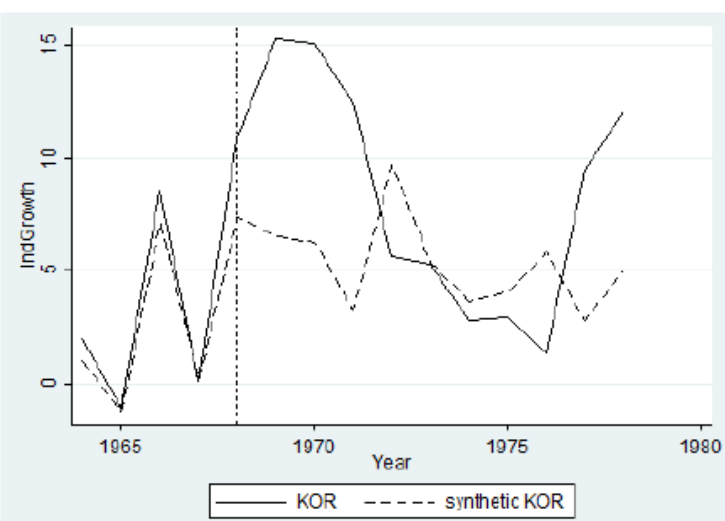
Agriculture. (a) Synthetic control (b) Placebos



Source: prepared by the authors based on the research data.

4.1.2 Industry

As for the industrial sector, we present the weighting units which show a combination of Brazil, India and Morocco as the one that best fits the data (Figure 2(a)). We can observe that the behaviour of the labour productivity growth in the synthetic industry of South Korea before the treatment follows closely that of real South Korea. However, after the opening of the market, the behaviour diverges during the period from 1969 to 1972. In these four years, the growth of labour productivity in the industrial sector of South Korea reached up to 15% in 1969 and 1970, approximately twice that observed in the synthetic control. This behaviour suggests that the industrial sector of South Korea, unlike the agricultural sector, indeed obtained a higher growth rate due to the trade opening of 1968.

Figure 2*Industry. (a) Synthetic control (b) Placebos*

Source: prepared by the authors based on the research data.

Observing Figure 2(b), it is clear that the results are significant at the level of 1/13, or 7.7% for the year 1966, which is below the highest significance level generally reported, of 10% for the period from 1969 to 1972. We note that the fits of the placebos are as good as those of the treated unit for most placebos. In eleven of them, the fits are sufficiently close to generate small gaps in the pre-treatment, which guarantees the quality of the significance test (Abadie et al., 2010).

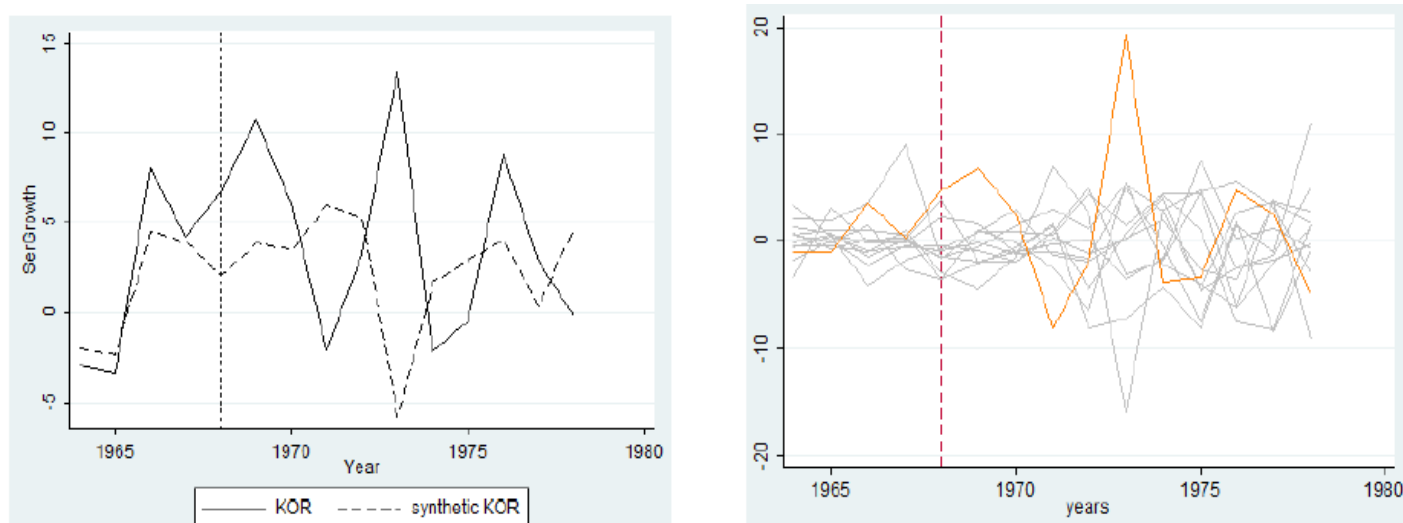
4.1.3 Services

The growth of labour productivity in the services sector of South Korea also seems to react to the trade opening in 1968. We present the weighting units which show that Brazil only is the best control for South Korea.

Figure 3(a) allows the visual inspection. The pre-treatment is good, except for the year 1966. Similar to the industrial sector, the growth rates rise to the level of 10% in 1969 and, throughout the period from 1968 to 1971, the growth rates are higher than in the synthetic control. After this first rise and the return to normal rates in 1972, there is a sharp drop, followed by a sharp rise in the growth rates of labour productivity. We could not understand this pattern through the trade opening mechanisms, therefore, we chose to ignore the results after the 1970s, although in 1973 there is a peak in the labour productivity growth rate of almost 15%, which is significant if we observe Figure 3(b). This is probably due to other reforms implemented in South Korea during this period and may also reflect economic fluctuations.

Figure 3

Services. (a) Synthetic control (b) Placebos



Source: prepared by the authors based on the research data.

Observing Figure 3(b) again, we can see that the results are significant at 1/13, or 7.7% (and also at 10%) for the initial years from 1968 to 1970, although the growth rates are more modest than in the industrial sector.

4.2 BOTSWANA

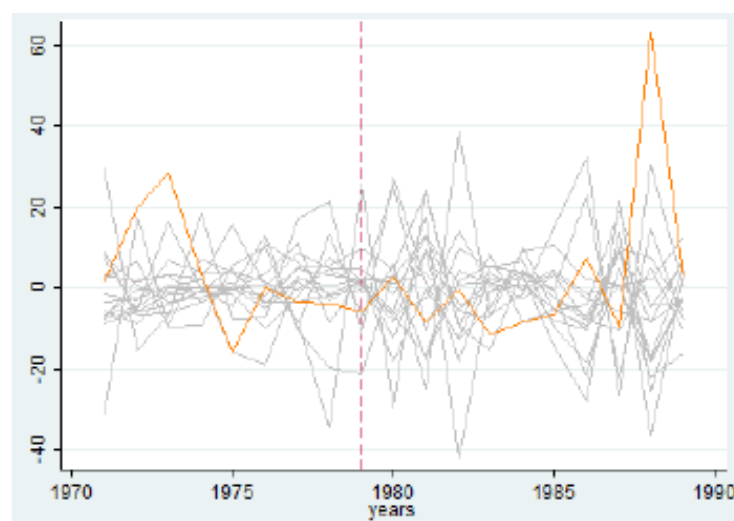
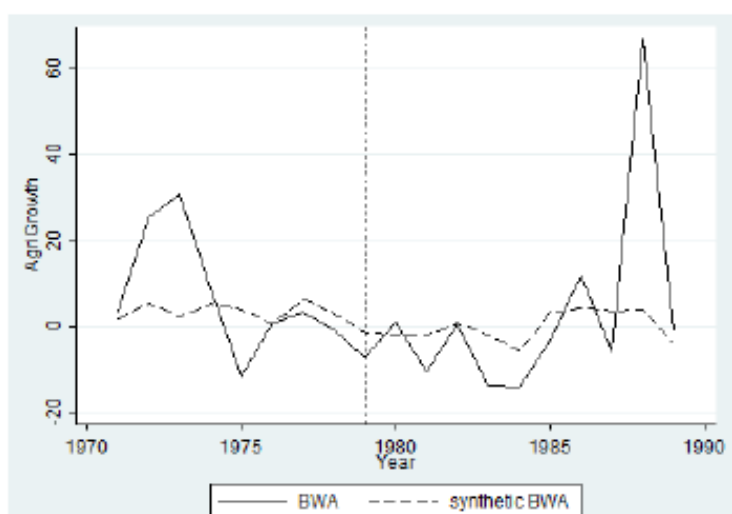
4.2.1 Agriculture

The estimates for the unit weights and the balance of the predictors for the growth of agricultural labour productivity in Botswana are presented. The best fit is a combination of Argentina, Kenya, South Africa and Venezuela. All the predictors are included, together with the 3 intermediate years of the pre-treatment of the outcome variable.

Figure 4(a) presents the visual fit. It can be observed that the first half of the pre-treatment is responsible for the relatively high Mean Squared Error. However, near the treatment, the synthetic series behaves much more closely to the reality of Botswana. The post-treatment is similar to the case of South Korea, where there is no peak in the rate of growth of the treated agricultural labour productivity. The placebos are presented in Figure 4(b), where the result does not seem statistically significant if all the placebos are kept or if those with the worst fit in the pre-treatment are removed. The trade opening does not seem to affect the treated outcome.

Figure 4

Agriculture. (a) Synthetic control (b) Placebos

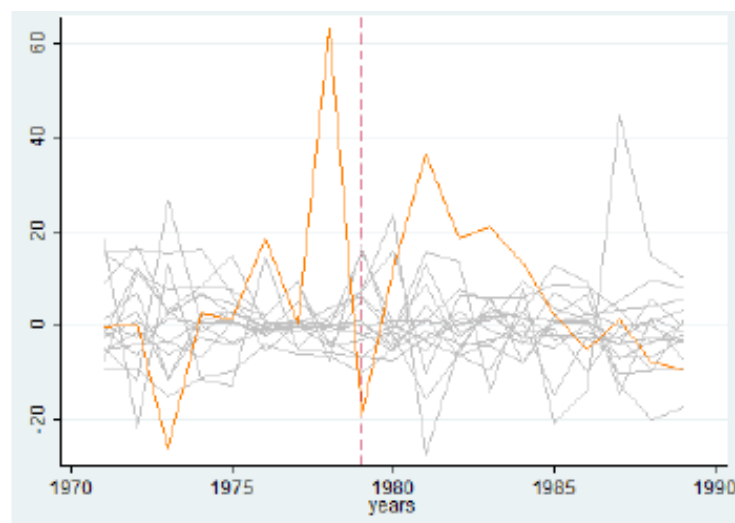
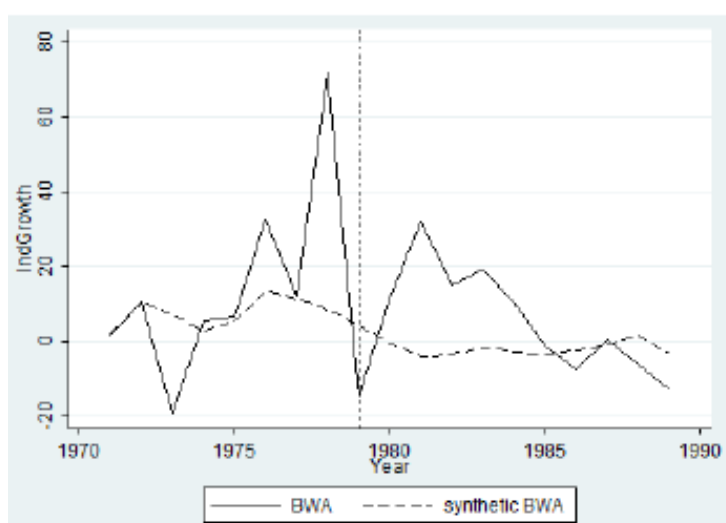


Source: prepared by the authors based on the research data.

4.2.2 Industry

The best fit uses Kenya as control. All the predictors are included in the last 3 years prior to the treatment. These years aim to control the extreme peak in the growth rates of industrial labour productivity in the last years prior to the treatment, especially in 1978. Unfortunately, it is not possible to capture this peak in the control, which ends up producing a poor fit. One way to theorise about this peak is to assume that the trade opening should be accounted for in the year 1978, instead of the year suggested by the methodology of Wacziarg and Welch (2008), which is 1979. It may be that Botswana was already in the process of rapid trade opening in 1978, but had not yet surpassed the limits defined by the authors. The problem with this logic would be that the result of 1979, a sharp drop in the growth rate, is difficult to explain.

The year 1979 was marked by a global oil shock, but the drop seems sharper in the Botswana data, which rules out the effect of a global recession. An internal recession in 1979 could explain the pattern, but according to the World Bank data, the growth rates were still positive in that year. The best explanation may come from Acemoglu et al. (2003). The authors explained that Botswana discovered many deposits of copper, nickel, coal and, mainly, diamonds. These mines attracted workers during the 1970s and proved to be highly productive. Apparently, 1979 marked the end of the structural transformation.

Figure 5*Industry. (a) Synthetic control (b) Placebos*

Source: prepared by the authors based on the research data.

Given that the growth of industrial labour productivity generated by a structural transformation in the mining sector would be difficult to control, it is understandable that the behaviour of the pre-treatment trajectory of Botswana is singular. Even so, we capture many years well, and the synthetic control seems to be, in a way, at the average of real Botswana. The post-opening growth is captured in the years from 1980 to 1985, where the growth rate of industrial labour productivity is above the control. Figure 5(b) presents the placebos. We can attest to the existence of a statistically significant growth rate for the years from 1981 to 1984, of 1/16, or 6.25% (below 10%). As we could observe in the agricultural sector, the pattern also fitted the trajectory of the South Korean industry.

4.2.3 Services

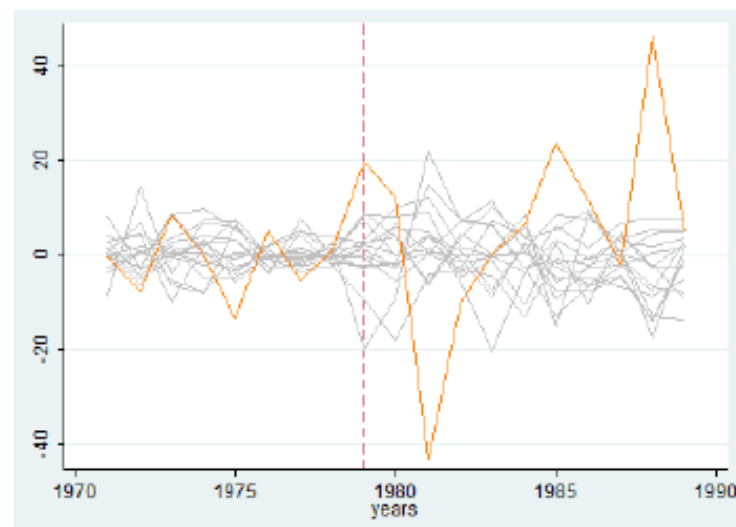
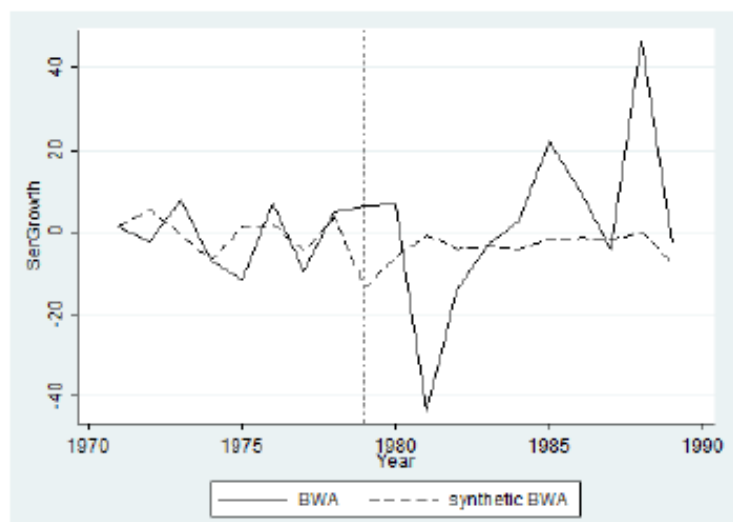
Finally, the growth of labour productivity in the services sector is the one that best fits Botswana, with a Mean Squared Error of 6.72, balancing of the predictors. Similar to the industrial sector, we chose to use the values of the last three years of the outcome as a predictor. In addition, we also used all the main predictors. The synthetic control was constructed by the combination of Colombia, Kenya and Venezuela.

The pre-treatment trajectory fits the services sector better than the agricultural and industrial sectors, as shown in Figure 6(a). The placebos are also better represented by the specification of the services sector, as can be observed in Figure 6(b). The opening seems to positively affect the growth of labour productivity in the services sector in the first two years after its implementation, 1979 and 1980, but the effect disappears afterwards, giving way to a large drop in 1981, followed by a recovery. The pattern is quite similar to that observed in

the services sector of South Korea. We chose to ignore the subsequent oscillations after 1981, since it is difficult to explain them using the mechanisms described in the introduction. The placebos are also significant at a level of 1/16, or 6.25% confidence (lower than 10%), for 1979 and 1980. The effect is not sufficiently large or persistent as in the industrial sector, just as it also happens in South Korea.

Figure 6

Services. (a) Synthetic control (b) Placebos



Source: prepared by the authors based on the research data.

4.3 DISCUSSION OF THE RESULTS

The similarity of the results for South Korea and Botswana after the trade opening is striking. Both presented an agricultural sector that did not have notable gains in the post-intervention period. The pattern of the industrial sector is also similar, with effects that last around 4 or 5 years in both countries after the opening, showing a sustained peak of growth of 10% for South Korea and a peak close to 40% for Botswana in 1982, with 20% afterwards. Finally, the services sector also performed quite similarly, with a shorter reaction period, of 2 or 3 years, with a much lower growth rate for Botswana and a peak of around 10% for South Korea and 20% for Botswana. In addition, both present the same peculiar pattern afterwards, with oscillating labour productivity growth rates.

We must bear in mind that not all the results are of the best quality. The results for the agriculture of South Korea and for the agriculture and industry of Botswana must be interpreted with caution, since they do not present a good correspondence with the pre-treatment. The other three results, industry and services of South Korea and services of Botswana, seem better and more reliable. Even so, the similar pattern in both cases reinforces the hypothesis of the effects, even in cases where the correspondence is

particularly poor, as in the industrial sector of Botswana. If we accept the existence of a previous structural transformation in the mining sector, as in Acemoglu et al. (2003), we can better understand the erratic pattern of this case. In addition, if the structural transformation continues to occur after the trade opening, the very high results found for Botswana may be the combination of the structural transformation in the mining sector with a greater efficiency arising from the trade opening.

This last concern, highlighted in this last paragraph, is also present in Billmeier and Naniccini (2013), where the results must be interpreted with caution, since the trade opening is usually accompanied by other reforms that may also increase productivity. Restricting the analysis to the years closest to the opening should be more reliable than the results after 5 years.

The possible interpretation for the positive results in the industrial and services sectors is related to the mechanisms presented in the introduction. We expected the tradable goods to react more strongly to the opening, since they are subject to the three channels discussed: the new inputs channel; the competitive impulse channel; and the selection effects, while the services sector is subject only to the new inputs channel, since it is protected from foreign competition by the high transport costs. The growth of industrial labour productivity reacted more strongly than that of the services sector, but the agricultural sector did not react. We do not have a convincing explanation for this, but we speculate that the agricultural sector in such poor economies (South Korea was a lower-middle-income country in 1968) is mainly subsistence agriculture, with low levels of human capital and, therefore, lower capacity to incorporate technology into its products.

5 FINAL CONSIDERATIONS

We studied the growth rates of sectoral labour productivity in two countries that opened to international markets, South Korea (1968) and Botswana (1979), using the synthetic control method of comparative case studies developed by Abadie and Gardeazabal (2003) and Abadie et al. (2010).

We found that the industrial sector seems to be the one that presents the greatest benefits of the trade opening, followed by the services sector. In the agricultural sector, the growth rate of labour productivity does not respond to the trade opening. The results are in agreement with the part of the literature that finds large effects for the industrial sector, as highlighted in the Literature Review section, but they fill the gap through the use of a quasi-experimental design, addressing the endogeneity criticism on the part of the panel data and

the lack of statistical rigour on the part of the informal case studies. As far as we know, this is the first study to corroborate these results with such a design.

The merits of this study are clear, but future studies could try to address some issues. Firstly, we used substitute variables for the predictors, since we could not find sectoral data. If the sectoral data were available, the fit could be much better. Secondly, the data on sectoral labour productivity were available only for some countries. If it were possible to access data from more countries, more comparisons could be made, as in the aggregate analysis of Billmeier and Naniccini (2013). Furthermore, our control base was the best we could obtain with the little data available. The inclusion of more countries could also contribute to the creation of a control base through regional aggregation, which would probably increase the pre-treatment fit, since this base would be more likely to include similar countries.

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EPISTEMIC CAPTURE IN ACADEMIC AGROECOLOGY: ANALYTICAL MATRIX, SUBEMOTÉPÜBI AND VALIDATION OF INDIGENOUS KNOWLEDGE

CAPTURA EPISTÊMICA NA AGROECOLOGIA ACADÊMICA: MATRIZ ANALÍTICA, SUBEMOTÉPÜBI E VALIDAÇÃO DOS SABERES INDÍGENAS

CAPTURA EPISTÊMICA EN LA AGROECOLOGÍA ACADÉMICA: MATRIZ ANALÍTICA, SUBEMOTÉPÜBI Y VALIDACIÓN DE LOS SABERES INDÍGENAS



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ABSTRACT

This study analysed the epistemology of academic agroecology starting from the hypothesis that the field, although it claims to be critical of the productivist paradigm and open to the dialogue of knowledges, frequently recomposes modern regimes of scientific validation under new terminology. The aim was to understand whether the presence of Indigenous, traditional and territorial knowledges structurally alters the criteria of legitimacy of knowledge or whether it remains subordinated to academic mediation. A qualitative, analytical-comparative and interdisciplinary approach was used, applying the Epistemic Capture Matrix and the Epistemic Capture Index to a corpus of thirty academic studies selected from three information systems: Cadernos de Agroecologia, Scopus and Google Scholar. The dimensions analysed were Validation Regime, Indigenous or Traditional Presence, Predominant Epistemology, Epistemic Authority, Relationship with the Territory, Epistemic Capture and Micro-recognition, termed subemotépübi. The results indicated a global incidence of epistemic capture of 0.73, with the highest occurrence in Google Scholar, followed by Cadernos de Agroecologia and Scopus. The analysis demonstrated that academic agroecology does not constitute a homogeneous field of capture, but neither does it fully break with the structural coloniality of validation criteria. Throughout much of the corpus, Indigenous and territorial knowledges appear as a reference or critical repertoire, without effectively reorganising the centres of epistemological authority. It is concluded that the concept-method Etnoagroecologizar, grounded in the Território-Ente arising from the experience with the Karão Jaguaribaras, offers a path of epistemological reorganisation in the face of the latifundium of knowledge in academic agroecology.

Keywords: Academic Agroecology. Epistemic Capture. Indigenous Epistemology. Território-Ente. Etnoagroecologizar.

RESUMO

Este estudo analisou a epistemologia da agroecologia acadêmica a partir da hipótese de que o campo, embora se afirme crítico ao paradigma produtivista e aberto ao diálogo de saberes, frequentemente, recompõe regimes modernos de validação científica sob nova terminologia. O objetivo foi compreender se a presença de saberes indígenas, tradicionais e territoriais

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altera estruturalmente os critérios de legitimidade do conhecimento ou se permanece submetida à mediação acadêmica. Foi utilizada a abordagem qualitativa, analítico-comparativa e interdisciplinar, com aplicação da Matriz de Captura Epistêmica e do Índice de Captura Epistêmica a um corpus de trinta estudos acadêmicos selecionados em três sistemas de informação: Cadernos de Agroecologia, Scopus e Google Acadêmico. As dimensões analisadas foram Regime de Validação, Presença Indígena ou Tradicional, Epistemologia Predominante, Autoridade Epistêmica, Relação com o Território, Captura Epistêmica e Microreconhecimento, denominado subemotépübi. Os resultados indicaram incidência global de captura epistêmica de 0,73, com maior ocorrência no Google Acadêmico, seguido dos Cadernos de Agroecologia e da Scopus. A análise demonstrou que a agroecologia acadêmica não constitui campo homogêneo de captura, mas tampouco rompe integralmente com a colonialidade estrutural dos critérios de validação. Em grande parte do corpus, saberes indígenas e territoriais comparecem como referência ou repertório crítico, sem reorganizar efetivamente os centros de autoridade epistemológica. Conclui-se que o conceito-método Etnoagroecologizar, fundamentado no Território-Ente advindo da experiência com os Karão Jaguaribaras, oferece uma vereda de reorganização epistemológica diante do latifúndio do saber na agroecologia acadêmica.

Palavras-chave: Agroecologia Acadêmica. Captura Epistêmica. Epistemologia Indígena. Território-Ente. Etnoagroecologizar.

RESUMEN

Este estudio analizó la epistemología de la agroecología académica a partir de la hipótesis de que el campo, aunque se afirma crítico del paradigma productivista y abierto al diálogo de saberes, frecuentemente recompone regímenes modernos de validación científica bajo una nueva terminología. El objetivo fue comprender si la presencia de saberes indígenas, tradicionales y territoriales altera estructuralmente los criterios de legitimidad del conocimiento o si permanece sometida a la mediación académica. Se utilizó el enfoque cualitativo, analítico-comparativo e interdisciplinario, con la aplicación de la Matriz de Captura Epistémica y del Índice de Captura Epistémica a un corpus de treinta estudios académicos seleccionados en tres sistemas de información: Cadernos de Agroecología, Scopus y Google Académico. Las dimensiones analizadas fueron Régimen de Validación, Presencia Indígena o Tradicional, Epistemología Predominante, Autoridad Epistémica, Relación con el Territorio, Captura Epistémica y Microreconocimiento, denominado subemotépübi. Los resultados indicaron una incidencia global de captura epistémica de 0,73, con mayor ocurrencia en Google Académico, seguido de los Cadernos de Agroecología y de Scopus. El análisis demostró que la agroecología académica no constituye un campo homogéneo de captura, pero tampoco rompe íntegramente con la colonialidad estructural de los criterios de validación. En gran parte del corpus, los saberes indígenas y territoriales comparecen como referencia o repertorio crítico, sin reorganizar efectivamente los centros de autoridad epistemológica. Se concluye que el concepto-método Etnoagroecologizar, fundamentado en el Território-Ente proveniente de la experiencia con los Karão Jaguaribaras, ofrece una vereda de reorganización epistemológica frente al latifundio del saber en la agroecología académica.

Palabras clave: Agroecología Académica. Captura Epistémica. Epistemología Indígena. Território-Ente. Etnoagroecologizar.

[...] neither agricultural scientists nor agroecologists are aware of the subordination of their research [...] many conduct research following the dominant method. (Norgaard; Sikor, 2002).

1 INTRODUCTION

Academic agroecology occupies an ambiguous place within contemporary disputes over knowledge, territory and the production of life. On the one hand, it presents itself as a critique of the productivist paradigm, the Green Revolution, technical diffusionism and disciplinary fragmentation. On the other, it often remains inscribed within the same validation protocols it claims to challenge. This tension is not peripheral; it constituted the very problem of this study.

The central question does not consist in denying the importance of agroecology as a scientific, political and territorial field. It consists in examining whether, within its academic production, there is a structural displacement of modern validation regimes or merely a recomposition of their grammar under critical vocabulary. The decisive question is less what the texts affirm about epistemic plurality and more who defines the problem, who establishes the method, which validity criteria are mobilised and what place is attributed to Indigenous, traditional and territorial knowledges.

The analytical position adopted starts from rescordia (BASTOS, 2026). This standpoint corresponds neither to an abstract distance from the academy nor to an unproblematic adherence to its established criteria. It is a matter of traversing the field from within, observing its silent prevalences, its centres of translation and its forms of partial recognition. One writes to the Academy and about it, but from the epistemological experience of the Karão Jaguaribaras.

From this perspective, academic agroecology is interrogated in its capacity to redistribute epistemic authority. The presence of Indigenous and traditional knowledges in the texts is not taken, in itself, as evidence of rupture. The analysis starts from the hypothesis that these knowledges may be admitted as source, repertoire, illustration, empirical experience or symbol of decolonisation, without occupying the place of a structuring criterion of knowledge.

It is in this mismatch between critical enunciation and effective validation that the concept of subemotépübi emerges. The term designates the micro-recognition granted to non-hegemonic knowledges and subjects when these are formally admitted but remain prevented from organising the method, the authority and the validity regime of the text. Recognition exists, but it does not effectively displace the epistemological centre of academic production.

The aim of this study was to analyse the predominant epistemological regime in academic agroecology through the Epistemic Capture Matrix and the Epistemic Capture Index, observing how the analysed production aligns, groups, subordinates or entangles Indigenous and traditional knowledges, practices and ontologies. The corpus is composed of thirty works intentionally selected among Cadernos de Agroecologia, Scopus and Google Scholar, from an initial search of 372 records.

The contribution of the article is organised on three planes. On the epistemological plane, it identifies the persistence of structural coloniality in the validation criteria of agroecological knowledge. On the methodological plane, it presents the Epistemic Capture Matrix and the Epistemic Capture Index as instruments of comparative reading. On the political-epistemic plane, it proposes Etnoagroecologizar as a concept-method capable of responding to the diagnosis of capture, displacing the validation of knowledge towards a situated relationship with the Território-Ente (Bastos, 2025; 2026).

2 THEORETICAL BACKGROUND

2.1 ANALYTICAL CATEGORIES

The analytical categories mobilised in this article do not function as an abstract repertoire. Território-Ente, Etnoagroecologizar, rescórdia, subemotépübi and digital neo-utilitarianism are proper concepts, formulated by the author in the course of the research and treated as authorial elaboration in academic circulation in press (Bastos *et al.*, 2025a; Bastos *et al.*, 2025b). They arose less as new words than as the need to name that which, without a name, continues to pass as normality: silent capture, the minimal concession, the translation that embraces and, at the same time, disarms.

To avoid terminological dispersion, this article takes as its central axis the Epistemic Capture Matrix, the Epistemic Capture Index and subemotépübi. The remaining categories operate as interpretative support. Rescórdia situates the place of enunciation; digital neo-utilitarianism assists the reading of scientific circulation; Território-Ente grounds the ontological displacement; and Etnoagroecologizar formulates the methodological response to the diagnosis of capture. The architecture is therefore concentrated: a few concepts conduct the analysis, while the others open the passages necessary for the field not to be read merely by its discursive surface.

The first supporting category is rescórdia. It designates the place of friction between paradigms that neither annul each other nor harmonise artificially. Rescórdia allows one to observe academic agroecology from within, without abandoning critique, and from without, without simulating absolute exteriority. It is the space in which the thesis positions itself before

the Academy: not to reject it entirely, but to reveal the conditions under which it recognises, translates or kidnaps original knowledges. At this edge, disagreement ceases to be noise and becomes a method of listening.

The second category is digital neo-utilitarianism. In its originating chapter, this concept is articulated with the utilitarian paradigms of Bentham (1974) and Mill (1859) and designates the contemporary regime of scientific circulation mediated by indexing, ranking, recurrence and formal adequacy.

Although algorithms and databases do not possess their own intention, their logic favours productions adjusted to stabilised formats of scientificity. Thus, investigating academic agroecology requires asking not only what is published, but what becomes visible, repeatable and recognisable as science.

The third category is *submotépübi*. The term designates the micro-recognition granted to Indigenous or traditional subjects, knowledges and ontologies when these appear in the text but do not reorganise its epistemic authority. *Submotépübi* occurs when the Indigenous presence is admitted as source, symbol, experience or repertoire, while the final validation remains academic, technical or institutional. It is a presence formally recognised but not authorised to displace the centre of validation of knowledge.

The fourth category is *Território-Ente*. In the horizon of the *Karão Jaguaribaras*, the territory is not a setting, context, resource or productive variable. It is living presence, active memory and a normative instance orienting practices and knowledges. When the territory is recognised as an *Ente* (Being), the very validation regime is displaced, for truth ceases to be merely demonstrated by an external protocol and comes to be lived, situated and regulated by the relations that sustain collective continuity.

The fifth category is *Etnoagroecologizar*. The concept arises as a noun-action and concept-method, linked to the experience with the onto-epistemology of the *Karão Jaguaribaras*. *Etnoagroecologizar* consists in analysing agroecological practice articulated with its ontological, epistemic, symbolic, ancestral and communal dimension.

It is not a matter of applying agroecology to original peoples, but of recognising that cultivation, education, cosmology, territoriality and transmission form one and the same fabric of existence and knowledge. Its function in this article is to respond to the problem identified by the matrix: if capture concentrates epistemic authority in the academic grammar, *Etnoagroecologizar* displaces validation towards the territory, collective memory and the peoples' own ways of producing knowledge.

2.2 ACADEMIC AGROECOLOGY AND STRUCTURAL COLONIALITY

Academic agroecology historically feeds on the resistance of traditional communities, on the critique of the productivist paradigm and on the denunciation of the socio-environmental effects of agricultural modernisation. However, this critical origin does not, in itself, guarantee an epistemological rupture with the validation regimes inherited from Eurocentred modernity. The field may incorporate the language of plurality without redistributing the authority that decides what counts as knowledge.

This tension is already announced in the warning of Norgaard and Sikor (2002), when they indicate that agricultural scientists and agroecologists are not always aware of the subordination of their research to the dominant method. The critique of productivism does not necessarily mean a critique of the modes of scientific validation that sustain the very organisation of research.

The problem, therefore, does not lie merely in the absence of original peoples or traditional communities in the corpus. In many cases, they appear. The question is the way in which they appear: as empirical context, cultural resource, example of sustainable practice, testimony, ancestrality evoked as epistemic authority effectively capable of reorganising the method and the validation criteria of knowledge. The difference between presence and authority is the axis of the analysis.

In this sense, the structural coloniality of academic agroecology is not manifested only in explicit declarations of scientific superiority. It operates through silent prevalences, naturalised validation criteria and reiterated forms of translation that maintain academic grammar as the final instance of intelligibility. Even when the text celebrates traditional knowledges, it may re-inscribe them in the condition of object of interpretation rather than as structuring foundation of the epistemological regime itself.

2.3 EPISTEMIC CAPTURE MATRIX AND EPISTEMIC CAPTURE INDEX

The Epistemic Capture Matrix was built as an instrument of ordinal qualitative coding. Its purpose is to identify, in each work of the corpus, the place occupied by Indigenous, traditional and territorial knowledges within the regime of scientific validation. The matrix does not measure only presence or absence; it seeks to locate who defines the problem, who validates the knowledge and what function is attributed to the territory.

Seven analytical dimensions were established: Validation Regime (VR), Indigenous or Traditional Presence (IP), Predominant Epistemology (E), Epistemic Authority (EA), Relationship with the Territory (RT), Epistemic Capture (EC) and Micro-recognition, or subemotépübi (MR).

In the Validation Regime, the scale ranges from VR1 to VR5. VR1 indicates exclusive academic validation; VR2, academic validation with referential incorporation of Indigenous or traditional knowledges; VR3, asymmetrical hybrid validation; VR4, shared hybrid validation; and VR5, structuring territorial-Indigenous validation.

In Indigenous or Traditional Presence, IP0 indicates absence; IP1, superficial mention; IP2, empirical incorporation; IP3, analytical participation; and IP4, epistemic protagonism. This dimension allows distinguishing the mere evocation of Indigenous or traditional subjects from their effective action in the architecture of the knowledge produced.

In Predominant Epistemology, four categories were adopted: AE, academic epistemology; HE, hybrid epistemology; TE, territorial epistemology; and IE, Indigenous epistemology. As for Epistemic Authority, EA1 corresponds to academic authority; EA2, technical-institutional; EA3, communal; EA4, shared; and EA5, Indigenous.

The Relationship with the Territory was classified from RT0 to RT5. RT0 indicates absence of the territory as an analytical dimension; RT1, territory as context; RT2, territory as resource; RT3, territory as sociocultural relation; RT4, territory as normative instance; and RT5, territory recognised as Território-Ente.

In Epistemic Capture, EC0 indicates absence of capture; EC1, conceptual extraction; EC2, academic translation; EC3, epistemic erasure; and EC4, methodological coloniality. Finally, Micro-recognition was classified as MR0, non-existent; MR1, symbolic; MR2, partial; and MR3, explicit collective.

The Epistemic Capture Index (ECI) was calculated from the Epistemic Capture variable. Occurrences of capture were considered to be all works classified in the categories EC1, EC2, EC3 and EC4. Works classified as EC0 remained in the denominator but did not integrate the numerator. The formula used was:

$$ICE = \frac{(n_{\{CE1\}} + n_{\{CE2\}} + n_{\{CE3\}} + n_{\{CE4\}})}{N} \quad (1)$$

This index ranges from 0 to 1. The closer to 0, the lower the incidence of epistemic capture; the closer to 1, the greater the recurrence of forms of capture in the corpus. The index does not intend to measure the differentiated intensity between modalities of capture. Its function is to offer a comparative synthesis of the frequency of epistemic capture among documentary bases, analytical sets and general tendencies of the corpus.

3 METHODOLOGY

In accordance with CNPq Ordinance No. 2,664/2026, the use of the autonomous agent Manus AI (version 1.6 Max) in the data analysis stage is declared. The tool was used for the automation and direct execution of data-cleaning scripts in a virtual environment. The

statistical parameters applied, the validation of the generated codes and the critical interpretation of all final results were conducted entirely by the human authors.

The research adopts a qualitative, analytical-comparative and interdisciplinary approach. The methodological design was structured to examine the validation regimes present in the production of academic agroecology, with attention to the treatment given to Indigenous, traditional and territorial knowledges, to ontologies, to the transmission of knowledge and to the epistemic authority attributed to the subjects of the field.

The search strategy was designed with the aim of constituting a comparable corpus of academic publications in agroecology. Three information systems were selected: Cadernos de Agroecologia, for its centrality in the Brazilian agroecological field; Scopus, for its function of international indexing; and Google Scholar, for the breadth of its documentary retrieval.

The search used, in the three databases, the same thematic descriptors associated with academic agroecology, knowledge construction, education for agroecology, epistemology, traditional knowledges, Indigenous knowledges, territory and traditional knowledge.

The query was carried out in Portuguese, French, English and Spanish, in order to broaden the retrieval of works linked to the agroecological debate in different linguistic circuits. The Boolean operators AND and OR were employed, with the aim of ensuring methodological traceability and thematic pertinence of the corpus.

The initial universe gathered 372 works: 117 from Cadernos de Agroecologia, 183 from Scopus and 72 from Google Scholar. Owing to the volume identified, an intentional analytical selection of thirty works was made, distributed equitably among the three systems: ten from Cadernos de Agroecologia, ten from Scopus and ten from Google Scholar.

The selection prioritised texts with greater thematic correspondence to the descriptors, access to the content, pertinence to the epistemological debate and a balanced distribution among the three databases. The inclusion and exclusion criteria derived directly from the descriptors used, with the inclusion of works that presented adherence to the field of academic agroecology and to the discussions on epistemology, territory, Indigenous knowledges, traditional knowledges and knowledge construction; texts without sufficient thematic correspondence or without minimal access to the content necessary for coding were excluded.

Even so, it is acknowledged that this is not an exhaustive systematic review, but a qualitative-comparative analysis of an intentional corpus. In Cadernos de Agroecologia, it is important to record that many works are extended abstracts, with reduced length and, in some cases, the absence of an abstract or full text.

Each selected work constituted a unit of analysis and was coded according to the seven dimensions of the Epistemic Capture Matrix. The coding was qualitative ordinal, applied by a single researcher, based on operational descriptors previously stabilised, in order to reduce impressionistic oscillations and make the comparison between the segments of the corpus more traceable. Reading was integral whenever the full text was available; in cases where the publication was restricted to an extended abstract or presented access limitations, the coding considered the reading of the extended abstract and the available textual elements.

Each textual unit was read according to guiding questions intended to make the matrix more auditable: who validates the knowledge? Who speaks and from which epistemic place? Which knowledge organises the argument? Does the territory appear as setting, resource, sociocultural relation, normative instance or Ente? Is there capture, translation, erasure or epistemic displacement? These questions oriented the passage from qualitative reading to ordinal coding, allowing the matrix to operate not as impressionistic marking but as a comparative instrument for analysing validation regimes.

The methodological procedure also assumes a tension proper to the research: to use demonstrative protocols required by the Eurocentred academy in order to fracture its own prevalence. It is not a matter of full adherence to the dominant validation regime, but of an operation of intellectual and political survival. In this horizon, the matrix functioned simultaneously as an analytical instrument and as a critique of the very academic conditions of the legitimization of knowledge.

4 RESULTS AND DISCUSSION

4.1 DISTRIBUTION OF EPISTEMIC CAPTURE IN THE CORPUS

The application of the Epistemic Capture Matrix to the thirty works allowed identifying the distribution of forms of capture, mediation, partial recognition and epistemic displacement in the corpus. The global incidence of epistemic capture was 0.73, a result of twenty-two works classified in the categories EC1, EC2, EC3 or EC4 in a universe of thirty analysed units.

Table 1

Synthesis of the Epistemic Capture Index by analysed database

Analysed database	Works	Epistemic capture	ECI	Predominant tendency
Cadernos de Agroecologia	10	7	0.70	Dialogue of knowledges with mediation

Scopus	10	6	0.60	Gradient between institutionalised critique and territorial fissures
Google Scholar	10	9	0.90	Approximation to situated knowledges with high conceptual extraction
Total	30	22	0.73	Epistemic capture: predominant.

Source: prepared by the author (2026).

This result indicates that epistemic capture appears as a predominant, though not absolute, tendency. The corpus does not reveal a homogeneous totality of capture, but a gradient of positions in which dominant academic validation, conceptual translation and partial recognition coexist with experiences of fissure, sharing and, in a few cases, a denser displacement of epistemic authority.

The distribution by segment showed a higher incidence of capture in Google Scholar, with an ECI of 0.90. Cadernos de Agroecologia presented an ECI of 0.70, while Scopus recorded an ECI of 0.60. This distribution should not be read as a simple hierarchy among databases, but as an indication of distinct modes of circulation, indexing and mediation of knowledge.

In Google Scholar, the breadth of documentary retrieval revealed more ambiguous forms of capture. Many texts approach situated, Indigenous and territorial knowledges, but do not fully break with the academic frame that organises, translates and legitimates the interpretation. Capture, in this block, is concentrated less in frontal erasure and more in conceptual extraction and partial recognition.

In Cadernos de Agroecologia, the production frequently appears linked to practice, to formative processes, to collective experiences and to territorialities. However, proximity to the territory and to the language of the dialogue of knowledges does not always alter the predominant validation regime. In many cases, territorial knowledges appear as reported experiences, exemplifying practices or empirical evidence of processes classified as agroecological.

In Scopus, a clearer gradient was observed between high-capture texts, institutionalised critical formulations and isolated cases of greater territorial or Indigenous density. Even when the research adopts insurgent or critical methodologies, academic grammar frequently remains the final instance of translation and legitimation. This suggests that epistemological critique can coexist with persistent structures of centralisation of scientific authority.

4.2 MICRO-RECOGNITION AND EPISTEMIC AUTHORITY

The most relevant result of the matrix lies not only in the frequency of capture, but in the place attributed to Indigenous and traditional knowledges when they enter the academic text. The presence of these knowledges does not necessarily equate to the redistribution of epistemic authority. Often, they traverse the page as a respected reference, exemplary practice, memory of resistance or ethical repertoire, but the key that opens and closes legitimacy remains kept by academic grammar.

It is at this point that subemotépübi becomes visible. It appears when original peoples, traditional communities or territorial knowledges are mentioned as important, ancestral, sustainable or resistant, but do not assume the function of establishing the criteria of truth, validity and interpretation. They enter the text, but they do not command its architecture. They are recognised, discursively, yet not authorised to reorganise the epistemological centre of scientific production.

The analysis demonstrated that even Indigenous authorship, when present, does not automatically guarantee a substantial transfer of epistemic authority. A text may contain Indigenous authorship and, even so, remain subordinated to academic protocols that translate, stabilise and validate the experience according to external criteria. Conversely, the audit also showed that the initial matrix had been conservative in recognising epistemic densities effectively present in part of the corpus. The analysed field, therefore, is not reduced to a homogeneous dynamic of capture.

This ambivalence is central. Epistemic capture does not depend only on who signs the text, but on who defines the problem, who orients the method, which ontology structures the interpretation and which validation regime prevails.

For this reason, the Epistemic Capture Matrix does not measure only presence; it also measures position. It asks who speaks, who validates, who translates and who remains as object of translation. The question seems simple, but its effect consists in tensioning the silent mechanisms of legitimation that sustain academic authority.

4.3 THE LATIFUNDIUM OF KNOWLEDGE IN ACADEMIC AGROECOLOGY

The critical synthesis of the results allows understanding academic agroecology as a field traversed by lines of concentration, mediation and fissure. It is neither a homogeneous space of total capture nor a territory already emancipated from its Eurocentric heritage. What becomes evident is a gradient of positions in which the legitimacy of knowledge is distributed unequally.

The expression "latifundium of knowledge" names this concentration of authority. Just as the territorial latifundium concentrates land and regulates access to production, the academic latifundium concentrates the validation criteria and regulates access to scientific legitimacy. Indigenous and traditional knowledges may circulate in this space, but they frequently do so through narrow corridors of translation and conditioned recognition.

In certain strands, epistemic authority remains concentrated in academic and technical-institutional protocols. In others, hybrid compositions arise in which territorial and Indigenous references appear in a denser way, although not always structuring. In rare cases, more consistent displacements towards the effective sharing of the validity of knowledge are observed.

This panorama prevents both the hasty celebration of an already consummated plurality and the reduction of the field to a uniform totality of capture. At the same time, it allows recognising that there are fissures, negotiations and partial displacements within academic agroecology itself. Even so, the analysis demonstrates that the critique of coloniality does not automatically convert into a reorganisation of the validation criteria. To a large extent, the field continues to operate through centres of translation, corridors of legitimacy and zones of mediation in which Indigenous knowledges are admitted but re-inscribed under dominant academic grammar.

4.4 ETNOAGROECOLOGIZAR AS A METHODOLOGICAL PATH

In counterpoint to subemotépübi, the experience with the Karão Jaguaribaras made it possible to structure a distinct configuration of ethnographing and epistemologising the Other. This configuration we name Etnoagroecologizar. The concept is presented neither as a theoretical adornment nor as a poetic closure of the diagnosis. It responds directly to the result of the matrix: where academic agroecology recognises Indigenous knowledges without displacing its centres of validation, Etnoagroecologizar proposes to redistribute the criteria of authority on the basis of the Território-Ente.

Etnoagroecologizar was generated in the course of the research as a noun-action and methodological concept. It is a matter of analysing agroecological practice in its ontological, epistemic, symbolic, ancestral and communal dimension, taking as reference the experiences of the Karão Jaguaribaras. In this horizon, to cultivate, to educate, to transmit, to listen and to inhabit the territory are not separate dimensions; they constitute one and the same fabric of existence, a set of epistemological parameters.

The process with this ethnic group traverses the experience of *être affectée*, in dialogue with Favret-Saada (1977), as a fabric in which interactions are consolidated in

reciprocal dialogues, in the interstices of observations and, often, in silence. The research is not organised as external data collection, but as situated implication, in which the presence of the researcher is also traversed by the territory, by times and by relations.

In this horizon, Território-Ente gains centrality. It is not limited to an interpretative category; it constitutes the ontological foundation of the research itself. The territory participates in the constitution of knowledge, regulates relations, organises times and defines the ethical limits of cultivation and coexistence. When recognised as an Ente, the validation regime is displaced, for truth is not merely demonstrated but lived and situated.

Etnoagroecologizar, therefore, does not merely propose a new nomenclature for agroecological practices. It proposes to reorganise the criteria of validation and production of knowledge on the basis of non-colonised parameters of existence, cultivation and education in the Território-Ente. It is at this point that the diagnosis of capture is converted into a passage towards an epistemological proposition of its own: the critique of the latifundium of knowledge ceases to operate merely as denunciation and comes to indicate a methodology of restitution, listening and territorial co-authorship.

5 CONCLUSION

The article analysed academic agroecology from the tension between its critical self-declaration and its effective validation regimes. The application of the Epistemic Capture Matrix and the Epistemic Capture Index allowed observing that the field does not present itself as a homogeneous totality, but as a space traversed by capture, mediation, partial recognition, fissures and occasional displacements. There are paths. There are fences. There are also narrow passages through which epistemic authority begins to move.

The global result of the ECI, equal to 0.73, indicates that epistemic capture remains predominant in the analysed corpus. The presence of Indigenous, traditional and territorial knowledges does not, in itself, guarantee a redistribution of epistemic authority. In most of the texts, these knowledges appear as reference, repertoire or empirical source, while the validation criteria remain linked to dominant academic grammar. Recognition, when it does not alter the validation regimes and the methodological criteria of knowledge, runs the risk of operating merely as a critical ornament.

The analysis of subemotépübi revealed that it can operate as a subtle form of maintenance of coloniality. The knowledge is recognised, but the centre that interprets it is not displaced; presence is admitted, but authority is not redistributed; the territory is invoked, but it is not always allowed to operate as a normative instance of knowledge. The fissure exists, but not every fissure breaks the wall. Some merely allow the wall to keep breathing.

In this way, the expression "latifundium of knowledge" synthesises this configuration. Academic agroecology, even when critical of productivism, can keep the criteria of scientific legitimacy concentrated.

However, the corpus also reveals fissures: there are texts in which Indigenous, territorial or communal knowledges appear not merely as object, but as foundation of the production of knowledge. This difference is decisive, for it displaces the analysis from presence to authority, from inclusion to validation, from declared listening to the effective reorganisation of the field.

It is in this interval between capture and fissure that Etnoagroecologizar emerges as a methodological path. The experience with the Karão Jaguaribaras, structured on the basis of the Território-Ente, makes it possible to propose an active, situated and relational epistemology, capable of tensioning the protocols that maintain the intellectual prevalence of established ideas.

The article concludes that overcoming the latifundium of knowledge in academic agroecology requires more than the dialogue of knowledges: it requires the effective redistribution of epistemic authority, the recognition of the territory as an Ente and the construction of validation criteria that do not kidnap original knowledges in the form of academic translation.

As a methodological contribution, the Epistemic Capture Matrix and the Epistemic Capture Index can be adapted to other interdisciplinary fields that declare themselves pluri-epistemic, intercultural or decolonial, but remain organised by academic-centred validation criteria.

Thus, their pertinence lies not in producing a neutral measure of capture, but in making visible the forms by which the recognition of non-hegemonic knowledges can coexist with the permanence of colonial centres of authority. The horizon of the article, therefore, is not to close the discussion, but to open a passage so that critique may operate as an instrument of listening and so that listening may reorganise the modes of producing and validating knowledge.

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THE EFFECTS OF CLIMATE CHANGE ON FOOD AND NUTRITION SECURITY: INTERFACES BETWEEN HEALTH, ENVIRONMENT AND SOCIETY

OS EFEITOS DAS MUDANÇAS CLIMÁTICAS SOBRE A SEGURANÇA ALIMENTAR E NUTRICIONAL: INTERFACES ENTRE SAÚDE, MEIO AMBIENTE E SOCIEDADE

LOS EFECTOS DEL CAMBIO CLIMÁTICO SOBRE LA SEGURIDAD ALIMENTARIA Y NUTRICIONAL: INTERFACES ENTRE SALUD, MEDIO AMBIENTE Y SOCIEDAD



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ABSTRACT

INTRODUCTION: Climate change represents one of the greatest global challenges of the 21st century, directly affecting human health, ecosystems, and food systems. Changes in temperature patterns, precipitation, and the occurrence of extreme weather events compromise agricultural production, the availability of natural resources, and the stability of supply chains, thereby impacting Food and Nutrition Security (FNS). These effects are particularly significant in developing countries, where socially vulnerable populations are highly dependent on productive systems sensitive to climate variability. In this context, understanding the interfaces among health, the environment, and society is essential to support adaptation and mitigation strategies aligned with the Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger and Sustainable Agriculture), SDG 3 (Good Health and Well-Being), and SDG 13 (Climate Action). **OBJECTIVE:** To analyse, through a literature review, the effects of climate change on food and nutrition security, highlighting its interfaces with health, the environment, and society, as well as its impacts on food availability, access, quality, and stability. **METHODOLOGY:** This study consists of a literature review conducted

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through systematic searches in the PubMed, LILACS, and SciELO databases. Articles published between 2020 and 2025 were selected based on thematic relevance, recency, and alignment with the study objectives. The final sample comprised 10 scientific studies, which were analysed using a descriptive and interpretative approach to identify evidence, convergences, and gaps related to the impacts of climate change on food and nutrition security. **RESULTS:** The analysed studies demonstrated that climate change significantly affects food systems by reducing agricultural productivity, causing biodiversity loss, degrading water resources, and altering the nutritional quality of foods. Extreme events such as droughts, floods, and heatwaves were associated with increased food insecurity, rising food prices, and the worsening of social and health inequalities. Furthermore, climate-related impacts were found to increase the vulnerability of populations living in poverty, contributing to a higher risk of malnutrition, food insecurity, and environmentally related diseases. **CONCLUSIONS:** Climate change exerts both direct and indirect influences on food and nutrition security, constituting a major challenge for public health, environmental sustainability, and social development. The findings highlight the need for integrated public policies, strengthened climate governance, the promotion of resilient and sustainable food systems, and the implementation of adaptation strategies capable of reducing vulnerabilities and protecting populations most exposed to environmental impacts. Understanding the interconnections among health, the environment, and society is essential for developing effective responses to the challenges posed by climate change.

Keywords: Climate Change. Food And Nutrition Security. Planetary Health. Public Health. Food Systems.

RESUMO

INTRODUÇÃO: As mudanças climáticas constituem um dos maiores desafios globais do século XXI, repercutindo diretamente sobre a saúde humana, os ecossistemas e os sistemas alimentares. Alterações nos padrões de temperatura, precipitação e ocorrência de eventos climáticos extremos comprometem a produção agrícola, a disponibilidade de recursos naturais e a estabilidade das cadeias de abastecimento, impactando a Segurança Alimentar e Nutricional (SAN). Esses efeitos são particularmente relevantes em países em desenvolvimento, onde populações socialmente vulneráveis apresentam maior dependência de sistemas produtivos sensíveis às variações climáticas. Nesse contexto, torna-se fundamental compreender as interfaces entre saúde, meio ambiente e sociedade para subsidiar estratégias de adaptação e mitigação alinhadas aos Objetivos de Desenvolvimento Sustentável (ODS), especialmente os ODS 2 (Fome Zero e Agricultura Sustentável), 3 (Saúde e Bem-Estar) e 13 (Ação Contra a Mudança Global do Clima). **OBJETIVO:** Analisar, por meio de revisão da literatura, os efeitos das mudanças climáticas sobre a segurança alimentar e nutricional, destacando suas interfaces com a saúde, o meio ambiente e a sociedade, bem como os impactos na disponibilidade, acesso, qualidade e estabilidade dos alimentos. **METODOLOGIA:** Trata-se de uma revisão da literatura realizada a partir de buscas sistematizadas nas bases de dados PubMed, LILACS e SciELO. Foram selecionados artigos publicados entre 2020 e 2025, considerando critérios de relevância temática, atualidade e aderência aos objetivos da pesquisa. A amostra final foi composta por 10 estudos científicos, analisados por meio de abordagem descritiva e interpretativa, buscando identificar evidências, convergências e lacunas relacionadas aos impactos climáticos sobre a segurança alimentar e nutricional. **RESULTADOS:** Os estudos analisados evidenciaram que as mudanças climáticas afetam significativamente os sistemas alimentares, promovendo redução da produtividade agrícola, perda da biodiversidade, degradação dos recursos hídricos e alterações na qualidade nutricional dos alimentos. Eventos extremos, como secas, enchentes e ondas de calor, foram associados ao aumento da insegurança alimentar, à elevação dos preços dos alimentos e ao agravamento das desigualdades sociais e de saúde. Além disso, observou-se que os impactos climáticos ampliam a vulnerabilidade de grupos

populacionais em situação de pobreza, contribuindo para o aumento do risco de desnutrição, insegurança alimentar e doenças relacionadas às condições ambientais. **CONSIDERAÇÕES FINAIS:** Conclui-se que as mudanças climáticas exercem influência direta e indireta sobre a segurança alimentar e nutricional, configurando-se como um importante desafio para a saúde pública, a sustentabilidade ambiental e o desenvolvimento social. Os resultados reforçam a necessidade de políticas públicas integradas, fortalecimento da governança climática, promoção de sistemas alimentares resilientes e sustentáveis e implementação de estratégias de adaptação capazes de reduzir vulnerabilidades e proteger populações mais expostas aos impactos ambientais. Compreender as conexões entre saúde, meio ambiente e sociedade é essencial para a construção de respostas efetivas frente aos desafios impostos pelas mudanças climáticas.

Palavras-chave: Mudanças Climáticas. Segurança Alimentar e Nutricional. Saúde Planetária. Saúde Pública. Sistemas Alimentares.

RESUMEN

INTRODUCCIÓN: El cambio climático constituye uno de los mayores desafíos globales del siglo XXI, repercutiendo directamente sobre la salud humana, los ecosistemas y los sistemas alimentarios. Las alteraciones en los patrones de temperatura, precipitación y ocurrencia de eventos climáticos extremos comprometen la producción agrícola, la disponibilidad de recursos naturales y la estabilidad de las cadenas de abastecimiento, impactando la Seguridad Alimentaria y Nutricional (SAN). Estos efectos son particularmente relevantes en países en desarrollo, donde las poblaciones socialmente vulnerables presentan mayor dependencia de sistemas productivos sensibles a las variaciones climáticas. En este contexto, resulta fundamental comprender las interfaces entre salud, medio ambiente y sociedad para fundamentar estrategias de adaptación y mitigación alineadas con los Objetivos de Desarrollo Sostenible (ODS), especialmente los ODS 2 (Hambre Cero y Agricultura Sostenible), 3 (Salud y Bienestar) y 13 (Acción por el Clima). **OBJETIVO:** Analizar, mediante una revisión de la literatura, los efectos del cambio climático sobre la seguridad alimentaria y nutricional, destacando sus interfaces con la salud, el medio ambiente y la sociedad, así como los impactos en la disponibilidad, acceso, calidad y estabilidad de los alimentos. **METODOLOGÍA:** Se trata de una revisión de la literatura realizada a partir de búsquedas sistematizadas en las bases de datos PubMed, LILACS y SciELO. Se seleccionaron artículos publicados entre 2020 y 2025, considerando criterios de relevancia temática, actualidad y adherencia a los objetivos de la investigación. La muestra final estuvo compuesta por 10 estudios científicos, analizados mediante un enfoque descriptivo e interpretativo, buscando identificar evidencias, convergencias y lagunas relacionadas con los impactos climáticos sobre la seguridad alimentaria y nutricional. **RESULTADOS:** Los estudios analizados evidenciaron que el cambio climático afecta significativamente los sistemas alimentarios, promoviendo la reducción de la productividad agrícola, la pérdida de biodiversidad, la degradación de los recursos hídricos y alteraciones en la calidad nutricional de los alimentos. Eventos extremos, como sequías, inundaciones y olas de calor, fueron asociados al aumento de la inseguridad alimentaria, al alza de los precios de los alimentos y al agravamiento de las desigualdades sociales y de salud. Además, se observó que los impactos climáticos amplían la vulnerabilidad de grupos poblacionales en situación de pobreza, contribuyendo al aumento del riesgo de desnutrición, inseguridad alimentaria y enfermedades relacionadas con las condiciones ambientales. **CONSIDERACIONES FINALES:** Se concluye que el cambio climático ejerce influencia directa e indirecta sobre la seguridad alimentaria y nutricional, configurándose como un importante desafío para la salud pública, la sostenibilidad ambiental y el desarrollo social. Los resultados refuerzan la necesidad de políticas públicas integradas, fortalecimiento de la gobernanza climática, promoción de sistemas alimentarios resilientes y sostenibles e implementación de estrategias de adaptación capaces de reducir vulnerabilidades y proteger a las poblaciones

más expuestas a los impactos ambientales. Comprender las conexiones entre salud, medio ambiente y sociedad es esencial para la construcción de respuestas efectivas frente a los desafíos impuestos por el cambio climático.

Palabras clave: Cambio Climático. Seguridad Alimentaria y Nutricional. Salud Planetaria. Salud Pública. Sistemas Alimentarios.

1 INTRODUCTION

Climate change constitutes one of the most complex and interdependent contemporary challenges faced by humanity, owing to its systemic impacts on natural ecosystems, productive systems, and socioeconomic dynamics. The increase in global average temperature, estimated at approximately 1.1 °C above pre-industrial levels, has been accompanied by the intensification of the frequency and magnitude of extreme weather events, such as prolonged droughts, heatwaves, floods, and severe storms (IPCC, 2021). These phenomena have caused significant changes in hydrological cycles, soil fertility, and agricultural productivity, directly compromising the stability of food systems. As a consequence, a worsening of food and nutrition insecurity on a global scale is observed, evidenced by the increase in the number of people facing hunger, which exceeds 700 million, according to recent estimates (FAO *et al.*, 2023).

The scientific literature is consistent in demonstrating that the impacts of climate change are unevenly distributed, affecting socially vulnerable populations more intensely. Developing countries, such as Brazil, present greater exposure and sensitivity to climate risks due to the combination of structural factors, including a high dependence on economic activities based on natural resources, persistent socioeconomic inequalities, and limitations in social protection and adaptation systems (Alpino *et al.*, 2022).

In this context, vulnerability is understood as the result of the interaction between exposure to risks, sensitivity of systems, and adaptive capacity, which contributes to the deepening of inequalities in health and nutrition. Thus, climate change not only intensifies food insecurity but also widens social inequities, constituting a critical determinant of public health in the 21st century (Santos; Duarte, 2022).

The impacts of climate change on food and nutrition security (FNS) are amplified by structural socioeconomic determinants, such as poverty, unemployment, rising food prices, limited access to land, and environmental degradation. These factors act in a synergistic and interdependent manner, intensifying the vulnerability of populations already exposed to precarious living conditions and compromising the human right to adequate food (Monteiro *et al.*, 2022).

Recent estimates indicate that, in 2022, between 691 and 783 million people faced hunger worldwide, reflecting a worsening of food insecurity conditions associated, among other factors, with climate change and global economic crises (FAO *et al.*, 2023).

There is consensus in the scientific literature that climate change intensifies the adverse effects on FNS, simultaneously affecting its four pillars: availability, access, utilisation, and stability of food. Evidence indicates that such impacts manifest

disproportionately among low-income populations, widening pre-existing social and nutritional inequalities (Santos; Duarte, 2022).

In this context, extreme weather events, such as prolonged droughts and floods, have been associated with increased acute food insecurity, especially in tropical and subtropical regions, where dependence on climate-sensitive agricultural systems is more pronounced (Santos *et al.*, 2023).

Food and Nutrition Security is defined as the condition in which all people have regular and permanent physical, social, and economic access to safe and nutritious food, in sufficient quantity, to meet their dietary needs and preferences, without compromising other essential needs (HLPE, 2022).

This concept is based on four interdependent pillars: availability, access, biological utilisation, and stability over time, which are directly influenced by environmental, economic, and social factors (FAO *et al.*, 2023).

The pillar of availability, in turn, presents high sensitivity to climate variability, since it is directly related to agricultural production, storage, logistics, and food trade. Changes in precipitation regimes, increases in global average temperatures, and greater frequency of extreme weather events have negatively impacted agricultural productivity. According to the IPCC, significant reductions in the yield of essential crops, such as maize and wheat, are already observed in various regions of the world, which compromises food supply and increases the volatility of food systems (IPCC, 2021).

Access to food, within the scope of Food and Nutrition Security (FNS), is defined as the physical, economic, and social capacity of individuals and populations to acquire adequate food in sufficient quantity and quality. This component is strongly influenced by economic determinants, such as income, relative food prices, and market functioning. Climate change interferes with this pillar by causing fluctuations in agricultural production and disruptions in supply chains, resulting in rising prices and reduced purchasing power, especially among low-income populations, who allocate a greater proportion of their income to food (FAO *et al.*, 2023; Salvajo *et al.*, 2023).

Food utilisation refers to the way the organism makes use of the ingested nutrients, being conditioned by the nutritional quality of foods, dietary practices, and conditions of health, sanitation, and access to potable water. Recent evidence indicates that the increase in atmospheric concentrations of carbon dioxide (CO₂), associated with thermal stress, may significantly reduce the content of essential micronutrients such as iron, zinc, and proteins in basic crops, compromising the nutritional value of foods and increasing the risks of nutritional deficiencies, particularly in vulnerable populations (Myers *et al.*, 2020).

The pillar of food stability concerns the capacity of food systems to ensure continuous access to food over time, even in the face of external shocks of a climatic, economic, or social nature. In this sense, extreme weather events, such as prolonged droughts, floods, and heatwaves, affect the regularity of food production and distribution, increasing price volatility and the frequency of episodes of food insecurity, particularly in regions with lower adaptive capacity (IPCC, 2022; Alpino *et al.*, 2022).

In Brazil, Food and Nutrition Security is normatively established by the Lei Orgânica de Segurança Alimentar e Nutricional (LOSAN), which recognises adequate food as a fundamental human right. This legal framework establishes FNS as an intersectoral public policy. However, recent evidence points to setbacks in national indicators, with a resurgence of food insecurity, aggravated by simultaneous climatic, economic, and health crises that weaken institutional response capacity and widen inequalities (Brasil, 2021; Rede Penssan, 2022).

Nutritional vulnerability may be conceptualised as the condition in which individuals or groups are exposed to risk factors that compromise regular access to adequate food, associated with a limited capacity to cope and adapt. It is a multidimensional construct, influenced by social, economic, and environmental determinants. Climate change intensifies this vulnerability by increasing exposure to risks, reducing the availability of resources, and limiting adaptive strategies, especially in contexts of structural inequality (Monteiro *et al.*, 2022; Santos *et al.*, 2023).

According to the IPCC, climate vulnerability results from the interaction between three fundamental dimensions: exposure to risks, sensitivity of systems, and adaptive capacity. Within this framework, populations living in poverty, family farmers, traditional communities, and residents of peripheral urban areas present greater susceptibility to climate impacts, due to the combination of high exposure and limited adaptive capacity (IPCC, 2021; FAO *et al.*, 2023).

Family farming, in the Brazilian context, constitutes a strategic component of FNS, being responsible for a significant share of the production of fresh food destined for domestic consumption. However, its high dependence on climatic conditions and its limited capacity to access technologies and credit make this sector particularly sensitive to changes in temperature and precipitation regimes, which compromises its productivity and sustainability (IBGE, 2020; Alpino *et al.*, 2022).

The expansion of the agricultural frontier, associated with deforestation and the predominance of productive systems based on monocultures, configures a development model that contributes to environmental degradation and to the worsening of climate change.

This process establishes a cycle of negative feedback, in which the degradation of ecosystems reduces environmental resilience and compromises the sustainability of food systems (Duarte; Santos, 2022; IPCC, 2022).

Extreme weather events, whose frequency and intensity have increased since the mid-20th century, represent one of the main manifestations of climate change. Phenomena such as heatwaves, severe droughts, floods, and wildfires directly impact food production, in addition to affecting human health, infrastructure, and the quality of life of populations, configuring a scenario of systemic risk (Salvajo *et al.*, 2023; IPCC, 2021).

Climate projections indicate that, even in scenarios of moderate mitigation, the increase in global temperature will continue to exert significant pressure on food systems. Warming above 2 °C in relation to pre-industrial levels could result in substantial losses of agricultural productivity, increased price volatility, and greater instability in food supply, intensifying the challenges for FNS (IPCC, 2022; FAO *et al.*, 2023).

Given this context, the need for the formulation and implementation of integrated public policies becomes evident, articulating strategies of mitigation and adaptation to climate change with actions aimed at promoting food and nutrition security. Such policies must prioritise the reduction of social inequalities, the protection of natural resources, and the strengthening of sustainable and resilient food systems, in line with the principles of sustainable development (Alpino *et al.*, 2022; Santos; Duarte, 2022).

Climate change has caused structural transformations in global food systems, affecting in an integrated manner the stages of food production, processing, distribution, and consumption. This phenomenon is embedded in a context of environmental and socioeconomic transition, in which the increase in global average temperature, the alteration of precipitation regimes, and the intensification of extreme weather events have compromised the stability of productive systems. Such changes directly affect food and nutrition security (FNS), increasing the exposure of populations to risks of scarcity, instability in supply, and deterioration of food quality (IPCC, 2021; HLPE, 2022).

Within the scope of food systems, agricultural production constitutes a critical component, highly sensitive to climate variability. Factors such as thermal stress, water irregularity, and soil degradation negatively affect crop yields, especially in tropical and subtropical regions, where production strongly depends on natural climatic conditions. This scenario compromises not only the quantity produced but also the predictability of food supply, weakening the security of agricultural systems and the sustainability of rural livelihoods (Myers *et al.*, 2020; Santos *et al.*, 2023).

In addition to the quantitative impacts, climate change also qualitatively affects the available foods. Studies indicate that the increase in the atmospheric concentration of carbon dioxide (CO₂), associated with conditions of environmental stress, may significantly reduce the content of essential micronutrients, such as iron, zinc, and proteins, in basic food crops. This phenomenon compromises the nutritional quality of diets, especially in populations that depend heavily on these foods, contributing to the worsening of nutritional deficiencies and to the deterioration of public health indicators (Myers *et al.*, 2020; Fanzo *et al.*, 2022).

Climate instability also exerts a direct influence on food supply chains, interfering with logistical processes, storage, and food distribution. Extreme weather events, such as floods, prolonged droughts, and storms, disrupt production and transport flows, raise operational costs, and impact price formation. As a result, a reduction in economic access to food is observed, especially among low-income populations, who present greater vulnerability to market fluctuations and lower capacity to absorb economic shocks (HLPE, 2022; Naicker *et al.*, 2025).

In this context, food insecurity is not restricted to the physical insufficiency of food but also encompasses the limitation of access to healthy and nutritionally adequate diets. Evidence points out that climate change contributes to the rising cost of nutritious foods, making balanced diets less accessible and widening nutritional inequalities between different social groups. This process reinforces the coexistence of multiple forms of malnutrition, such as undernutrition, micronutrient deficiency, and overweight, configuring a scenario of complex nutritional transition (Springmann *et al.*, 2021; Lloyd *et al.*, 2024).

Populations in situations of socioeconomic vulnerability present lower adaptive capacity in the face of climate impacts, owing to structural limitations that include low income, lower educational attainment, precarious insertion in the labour market, and fragility of social protection policies. These factors condition exposure and sensitivity to risks, widening the adverse effects of climate change on food and nutrition security and deepening already existing inequalities (Alpino *et al.*, 2022; Monteiro *et al.*, 2022).

In the Brazilian context, these vulnerabilities are intensified by marked regional inequalities and by the significant dependence on family farming for domestic food supply. Although this sector plays a strategic role in food production, its high sensitivity to climatic conditions and its limited access to technologies and credit make it particularly susceptible to changes in temperature and precipitation patterns. As a consequence, events such as droughts, rainfall irregularity, and heatwaves compromise the productivity, income, and food security of rural populations (IBGE, 2020; Silva *et al.*, 2024).

Recent reports show that extreme weather events have become more frequent and intense across Brazilian territory, affecting both rural and urban areas. These events directly impact food security by causing agricultural losses, compromising supply infrastructure, and affecting food distribution logistics, in addition to generating indirect effects on the health and living conditions of the population (Salvajo *et al.*, 2023; IPCC, 2021).

The scientific literature highlights that the impacts of climate change on FNS result from the complex interaction between environmental, economic, and social factors, and cannot be analysed in isolation. Thus, food insecurity should be understood as a multidimensional and dynamic phenomenon, whose intensity is amplified by the contemporary climate context and by structural inequalities (Fanzo *et al.*, 2022; Santos; Duarte, 2022).

Given this scenario, the formulation of integrated public policies becomes imperative, articulating strategies of mitigation and adaptation to climate change with actions aimed at promoting food and nutrition security. These policies should prioritise the reduction of social inequalities, the strengthening of local food systems, the protection of natural resources, and the adoption of sustainable agricultural practices, contributing to the construction of more resilient and equitable systems (HLPE, 2022; Silva *et al.*, 2024).

Additionally, the existence of relevant gaps in scientific production is observed, especially regarding the integrated analysis between extreme weather events and nutritional vulnerability in low-income populations. The identification of these gaps highlights the need for studies that deepen the understanding of the interrelations between climate, food, and social inequalities, supporting the formulation of more effective strategies to combat food insecurity (Naicker *et al.*, 2025; Lloyd *et al.*, 2024).

Thus, the understanding of the impacts of climate change on food and nutrition security, in the light of multiple determinants and different socioeconomic contexts, proves fundamental to support public policies and adaptation strategies capable of reducing inequalities and promoting more resilient and sustainable food systems (IPCC, 2021; Fanzo *et al.*, 2022).

From this perspective, the VigiSAN survey, conducted in 2021 by the Rede Brasileira de Pesquisa em Soberania e Segurança Alimentar e Nutricional (PenSSAN), evidenced the magnitude of food insecurity in Brazil. Approximately 55% of Brazilian households experienced some degree of food insecurity, with around 9% being in a severe situation. This condition proved more pronounced in rural areas, reaching approximately 12% of households. Furthermore, only 44% of the population presented full access to food security, evidencing the worsening of inequalities in the country (PenSSAN, 2021; FAO, 2022).

2 THEORETICAL FRAMEWORK

Concept of Food and Nutrition Security

Food and Nutrition Security (FNS) constitutes a central concept in the global agendas of public health and sustainable development, being defined as the condition in which all people have regular and permanent physical, social, and economic access to safe food, of quality and in sufficient quantity to meet their nutritional needs and dietary preferences, without compromising other essential needs. It is a multidimensional construct that transcends the mere availability of food, incorporating aspects related to equity, sustainability, and human dignity, in line with the principles of the Human Right to Adequate Food (FAO *et al.*, 2023; HLPE, 2022).

The conceptual framework of FNS is structured around four interdependent pillars: availability, access, utilisation, and stability. Availability refers to the physical existence of food, resulting from agricultural production, stocks, and trade; access is related to the economic and social capacity to acquire these foods; utilisation involves nutritional quality, dietary practices, and the health conditions that allow adequate biological use of nutrients; and stability concerns the continuity of these conditions over time, even in the face of external shocks. These pillars operate in an integrated manner, being mutually dependent for the guarantee of food security (HLPE, 2022; FAO *et al.*, 2023).

The pillar of food availability is intrinsically linked to the dynamics of productive systems and to environmental conditions, including climatic, technological, and economic factors. Agricultural production, the main source of food supply, depends on variables such as soil fertility, water availability, and adequate climatic conditions, which makes this pillar particularly sensitive to environmental changes and to processes of ecological degradation. Thus, the guarantee of food availability is directly associated with the sustainability of agricultural systems and with the capacity for large-scale production (FAO *et al.*, 2023).

Access to food, in turn, is strongly conditioned by socioeconomic determinants, such as income, food prices, market functioning, and public social protection policies. Even in contexts of adequate availability, food insecurity may persist due to the inability of certain social groups to acquire sufficient and nutritious food, evidencing the centrality of social inequalities in the determination of FNS. In this sense, access constitutes one of the main points of vulnerability in contemporary food systems (HLPE, 2022).

In the Brazilian context, Food and Nutrition Security is institutionalised by the Lei Orgânica de Segurança Alimentar e Nutricional (LOSAN), which recognises adequate food as a fundamental human right and establishes FNS as a State policy. LOSAN reinforces the need for intersectoral actions that integrate health, social assistance, agriculture, and

education, aiming to guarantee universal access to adequate and healthy food. This approach evidences that FNS should be understood not only as a food issue but as a structuring element of public policies aimed at promoting equity and social justice (Brasil, 2006).

Climate Change: Theoretical Basis

Climate change is defined as long-term alterations in the average patterns of the Earth's climate, including variations in temperature, precipitation, winds, and the occurrence of extreme events. These changes result from both natural processes and anthropogenic influences, it being currently widely recognised that human activities constitute the main driving factor of the transformations observed since the pre-industrial era. The increase in the concentration of greenhouse gases (GHGs) in the atmosphere has intensified the natural greenhouse effect, promoting global warming and triggering systemic impacts on ecosystems and socioeconomic systems (IPCC, 2021; NASA, 2023).

The anthropogenic causes of climate change are directly associated with the burning of fossil fuels, deforestation, agricultural expansion, and changes in land use. These processes result in the emission of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), the main gases responsible for global warming. Estimates indicate that the concentration of atmospheric CO₂ has already exceeded 420 ppm, a value significantly higher than pre-industrial levels, reflecting the intensification of human activities and their impacts on the global climate system (IPCC, 2021; NOAA, 2023).

The scientific evidence of climate change is widely documented and includes the increase in global average temperature, the rise in sea level, the melting of glaciers, and the greater frequency and intensity of extreme weather events, such as droughts, floods, heatwaves, and storms. According to the IPCC, the global average temperature has already increased by approximately 1.1 °C in relation to pre-industrial levels, with projections indicating the possibility of exceeding 1.5 °C in the coming decades if there is no significant reduction in GHG emissions (IPCC, 2021; WMO, 2023).

Given this scenario, the concepts of mitigation, adaptation, and resilience stand out as fundamental pillars in confronting climate change. Mitigation refers to strategies aimed at reducing greenhouse gas emissions or increasing carbon sinks, while adaptation involves adjustments in natural and human systems to reduce vulnerability and the damage associated with climate impacts. Resilience, in turn, concerns the capacity of systems to absorb, respond to, and recover from adverse events, maintaining their essential functions (IPCC, 2022; UNFCCC, 2021).

The scientific literature highlights that the integration between mitigation and adaptation is essential for the construction of more resilient and sustainable systems, especially in contexts of high socio-environmental vulnerability. In this sense, public policies and global strategies have emphasised the need for coordinated actions that consider not only the reduction of emissions but also the strengthening of the adaptive capacity of populations and productive systems. This integrated approach is fundamental to minimise the impacts of climate change and to promote sustainable development on a global scale (IPCC, 2022; FAO, 2023; UNEP, 2022).

Impacts of Climate Change

Climate change has significantly impacted food availability by compromising agricultural production in different regions of the world. The increase in global average temperatures, associated with the irregularity of precipitation and the greater incidence of extreme events, such as droughts and floods, has reduced the productivity of essential crops, such as rice, maize, and wheat. Moreover, processes of soil degradation, intensified by inadequate agricultural practices and climate change, contribute to the loss of productive capacity, directly affecting food supply and the sustainability of agricultural systems (IPCC, 2021; FAO *et al.*, 2023).

With regard to access to food, climate change exerts an indirect, yet significant, influence through rising prices and market instability. The reduction in agricultural production, combined with the disorganisation of supply chains, results in increased food costs, impacting low-income populations disproportionately. This scenario widens socioeconomic inequalities and limits access to adequate diets, especially in developing countries, where family income is more sensitive to price fluctuations (HLPE, 2022; Springmann *et al.*, 2021).

Food utilisation, understood as the biological use of nutrients, is also affected by climate change. Scientific evidence indicates that the increase in the concentration of carbon dioxide (CO₂) in the atmosphere is associated with the reduction of the content of essential micronutrients, such as iron and zinc, in basic food crops. This phenomenon compromises the nutritional quality of foods and may aggravate conditions of nutritional deficiency, especially in populations that depend on these foods as their main source of nutrients, negatively impacting public health (Myers *et al.*, 2020; Fanzo *et al.*, 2022).

The pillar of food stability is particularly sensitive to the intensification of extreme weather events. The recurrent occurrence of prolonged droughts, floods, heatwaves, and storms compromises the regularity of food production and distribution, generating instability in supply and greater price volatility. This context increases the frequency of episodes of food

insecurity, especially in regions with low capacity for adaptation and response to climate shocks (IPCC, 2022; FAO *et al.*, 2023).

In an integrated manner, the impacts of climate change on the different pillars of FNS evidence the complexity and interdependence of food systems. The food insecurity resulting from this process is not limited to the scarcity of food but involves economic, nutritional, and social dimensions, configuring a multidimensional phenomenon. In this sense, climate change acts as a factor that amplifies existing inequalities, requiring articulated responses that integrate policies of mitigation, adaptation, and the promotion of sustainable and resilient food systems (Fanzo *et al.*, 2022; HLPE, 2022).

Social Determinants and Vulnerability

The social determinants of health constitute structural factors that influence the living conditions, well-being, and morbidity patterns of populations, being fundamental for the understanding of inequalities in health and nutrition. In this context, variables such as income, educational attainment, occupation, and housing conditions play a central role in the determination of access to essential resources, including adequate food. Poverty, in particular, constitutes one of the main determinants of food insecurity, by limiting the capacity to acquire food of quality and in sufficient quantity, contributing to the perpetuation of intergenerational cycles of vulnerability (WHO, 2010; FAO *et al.*, 2023).

Social inequality, in turn, acts as a structuring factor of health inequities, since it distributes resources and opportunities unevenly among different population groups. In societies marked by a high concentration of income, greater exposure of vulnerable populations to adverse conditions is observed, including food insecurity, housing precariousness, and limited access to health and education services. These disparities reflect not only economic differences but also historical and political processes that condition access to basic rights, widening social vulnerabilities (Solar; Irwin, 2010; Marmot *et al.*, 2020).

Education constitutes a strategic social determinant, since it directly influences the capacity of individuals to access information, make informed decisions, and adopt healthy practices. Higher levels of educational attainment are associated with better health conditions, greater food security, and greater capacity to adapt to adverse contexts, including those related to climate change. On the other hand, low educational attainment limits access to work and income opportunities, reinforcing situations of vulnerability and food insecurity (Cutler; Lleras-Muney, 2010; FAO *et al.*, 2023).

Work and employment conditions also play a determining role in the configuration of social and nutritional vulnerability. Insertion in precarious, informal, or low-wage employment reduces the economic stability of families, compromising regular access to adequate food.

Furthermore, job insecurity and the absence of social protection increase exposure to social and health risks, evidencing the interdependence between labour conditions, income, and food security (ILO, 2021; Monteiro *et al.*, 2022).

Territory, understood as a geographically and socially constructed space, directly influences exposure to risks and the availability of resources, configuring itself as a central element in the analysis of vulnerability. Peripheral regions, isolated rural areas, and territories marked by precarious infrastructure present greater susceptibility to food insecurity and health inequities. In this context, vulnerability may be understood as the result of the interaction between exposure to risks, sensitivity of systems, and adaptive capacity, being strongly influenced by social and environmental determinants. This approach allows health inequities to be understood as complex, multidimensional, and socially determined phenomena (IPCC, 2021; Birkmann *et al.*, 2013).

Extreme Weather Events

Extreme weather events constitute one of the most evident manifestations of contemporary climate change, characterised by the increase in the frequency, intensity, and duration of phenomena such as droughts, floods, and heatwaves. These events have direct implications for natural and socioeconomic systems, significantly affecting food and nutrition security and the health of populations. Scientific evidence indicates that such phenomena have been intensifying since the mid-20th century, as a result of global warming induced by anthropogenic activities (IPCC, 2021; IPCC, 2022).

Prolonged droughts represent one of the main climate events with a direct impact on food production, especially in regions dependent on rainfed agriculture. The reduction in water availability compromises crop development, decreases agricultural productivity, and may lead to the total loss of harvests, affecting food availability and the income of farmers, especially in developing countries. Moreover, water scarcity impacts livestock production and agri-food systems as a whole (FAO *et al.*, 2023; Myers *et al.*, 2020).

Floods, in turn, significantly affect the productive and logistical infrastructure of food systems. Inundations may destroy crops, contaminate soils and water sources, and compromise roads, warehouses, and distribution networks. These impacts result in interruptions in food supply, increased post-harvest losses, and rising prices, hindering access to food, especially for populations in situations of vulnerability (HLPE, 2022; Naicker *et al.*, 2025).

Heatwaves constitute another extreme weather event with relevant repercussions on agricultural production and human health. Elevated temperatures affect crop growth, reduce productivity, and alter the nutritional quality of foods. In the field of health, heatwaves are

associated with an increase in heat-related diseases, dehydration, the worsening of chronic conditions, and a rise in mortality, especially among the most vulnerable groups, such as the elderly and exposed workers (IPCC, 2021; WHO, 2021).

In an integrated manner, extreme weather events compromise the stability of food systems, simultaneously affecting the production, supply, and access to food, in addition to directly impacting the health of populations. These phenomena contribute to the increase in food and nutrition insecurity, especially in contexts of socioeconomic vulnerability, where the capacity for adaptation is limited. Thus, the understanding of these events as critical determinants of health and food security is fundamental for the development of mitigation and adaptation strategies that promote more resilient and sustainable systems (IPCC, 2022; FAO *et al.*, 2023).

Global and Brazilian Scenario

The global scenario of food and nutrition security has deteriorated in recent decades, reflecting the complex interaction between climatic, economic, and geopolitical factors. Recent estimates indicate that between 691 and 783 million people faced hunger worldwide in 2022, evidencing a setback in the advances previously achieved. Furthermore, around 2.4 billion people experienced some degree of food insecurity, which demonstrates the persistence of structural inequalities and the fragility of global food systems in the face of simultaneous crises, such as climate change, conflicts, and economic instability (FAO *et al.*, 2023).

Food insecurity on a global scale is not limited to the quantitative insufficiency of food but also involves the difficulty of access to healthy and nutritionally adequate diets. Studies point out that approximately 3.1 billion people in the world cannot afford the cost of a healthy diet, which reinforces the economic dimension of food insecurity and evidences the unequal distribution of food resources. This scenario is aggravated by the increase in food prices, driven by extreme weather events and by the instability of global supply chains (FAO *et al.*, 2023).

In the Brazilian context, a significant worsening of food insecurity is observed in recent years, characterising a scenario of setback after important advances registered in previous decades. Data from the Inquérito Nacional sobre Insegurança Alimentar no Contexto da Pandemia da COVID-19 (VigiSAN) indicate that, in 2021, approximately 55% of Brazilian households lived with some degree of food insecurity, with around 9% being in a severe situation, characterised by the deprivation of food (Rede PenSSAN, 2021).

Regional inequalities in Brazil intensify this picture, with a higher prevalence of food insecurity in the North and Northeast regions, as well as in rural areas and urban peripheries.

In these regions, factors such as low income, labour informality, and limited access to public social protection policies contribute to greater food vulnerability. Furthermore, Black populations, women heads of family, and traditional communities present a higher risk of food insecurity, evidencing the intersectionality of social inequalities in the country (Rede PenSSAN, 2021; FAO *et al.*, 2023).

Given this panorama, it becomes evident that, both in the global and in the Brazilian scenario, food and nutrition security is profoundly conditioned by structural and contextual determinants. The recent worsening of indicators reflects not only cyclical crises but also systemic fragilities in the models of production, distribution, and access to food. In this sense, the strengthening of public policies, the promotion of sustainable food systems, and the reduction of social inequalities constitute essential strategies for confronting food insecurity at different scales (FAO *et al.*, 2023; Rede PenSSAN, 2021).

Global Agenda and Strategic Responses

Climate change has consolidated itself as one of the main global challenges of the 21st century, repercussing directly on productive systems, human health, and food and nutrition security. In this context, the 2030 Agenda for Sustainable Development emerges as an international strategic framework by integrating economic, social, and environmental goals aimed at overcoming hunger, promoting health, and protecting the planet. Among its objectives, SDG 2 (Zero Hunger and Sustainable Agriculture), SDG 3 (Good Health and Well-Being), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) stand out, which are directly articulated with the need to transform contemporary food systems into more resilient and inclusive models (ONU, 2015; FAO *et al.*, 2023).

The interdependence between climate, food production, and public health evidences that food insecurity cannot be confronted by isolated actions. Extreme events, such as prolonged droughts, floods, and rising average temperatures, have reduced agricultural productivity, increased post-harvest losses, and pressured food prices, compromising the access of the most vulnerable populations. Such phenomena particularly affect low- and middle-income countries, where dependence on climate-sensitive agricultural systems is greater and social protection mechanisms are still insufficient. Thus, the strengthening of integrated policies becomes essential to mitigate adverse effects and ensure food stability on a global scale (IPCC, 2023; WHO, 2023).

Among the most relevant strategic responses, the promotion of climate-resilient agriculture stands out, characterised by the adoption of productive practices capable of increasing environmental adaptation, reducing greenhouse gas emissions, and ensuring sustainable productivity. Techniques such as efficient water management, crop

diversification, recovery of degraded soils, and the use of adapted seeds have been pointed out as fundamental for expanding the response capacity of territories in the face of environmental changes. In addition to their ecological benefits, such measures contribute to income generation, rural economic stability, and the maintenance of food supply, aligning directly with the goals of SDG 2 and SDG 13 (FAO, 2021; IPCC, 2023).

Agroecology also presents itself as a robust strategy in the simultaneous confrontation of hunger, environmental degradation, and social inequalities. By valuing traditional knowledge, biodiversity, short marketing circuits, and local production, this model strengthens rural communities and promotes healthier and more diversified diets. Moreover, agroecological systems tend to present greater resilience in the face of climate shocks, owing to biological diversity and lower dependence on external inputs. In this sense, agroecology contributes not only to productive sustainability but also to SDG 12, by stimulating responsible patterns of production and consumption (HLPE, 2019; Altieri; Nicholls, 2020).

Finally, the effectiveness of global responses depends on the consolidation of intersectoral public policies and social protection mechanisms that ensure regular access to adequate food, especially in contexts of climate crisis. Income transfer programmes, school feeding, public purchases from family farming, and nutritional surveillance are instruments recognised for reducing vulnerabilities and promoting equity. Thus, the construction of sustainable food systems requires integrated governance among health, agriculture, social assistance, and the environment, reaffirming that the fight against hunger and climate change must occur in a simultaneous and coordinated manner (FAO *et al.*, 2023; Brasil, 2024).

3 METHODOLOGY

The present research is characterised as an integrative literature review, with a qualitative approach, descriptive nature, and exploratory character, developed with the purpose of critically analysing the scientific evidence regarding the impacts of climate change on Food and Nutrition Security (FNS). The choice of this methodological design is based on the possibility of bringing together results from studies with different methodological designs, allowing an expanded synthesis of the knowledge available on a complex and multidimensional theme. According to Gil (2020), bibliographic research enables theoretical deepening, the systematisation of knowledge already produced, and the identification of relevant scientific gaps.

The bibliographic search was carried out systematically in the databases Scientific Electronic Library Online (SciELO), PubMed/MEDLINE, Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), and Biblioteca Virtual em Saúde (BVS), as they

concentrate scientific productions of relevance in the areas of public health, nutrition, epidemiology, and the environment. Additionally, technical documents and institutional reports published by reference international bodies, such as the Food and Agriculture Organization, World Health Organization, and Intergovernmental Panel on Climate Change, were consulted, with a view to complementing the theoretical and contextual basis of the study.

For the search strategy, controlled descriptors from the DeCS (Descritores em Ciências da Saúde) and MeSH (Medical Subject Headings) vocabularies were used, associated with free keywords and the Boolean operators AND and OR. Among the main terms employed, the following stand out: "mudanças climáticas", "segurança alimentar", "insegurança alimentar", "nutrição", "climate change", "food security", "food insecurity", and "nutrition". The combinations of the descriptors were adapted according to the specificities of each database, aiming at greater sensitivity and precision in the retrieval of studies.

The inclusion criteria comprised: a) original scientific articles, systematic reviews, integrative reviews, dissertations, and theses; b) publications available in full; c) studies published between the years 2020 and 2025; d) Portuguese, English, or Spanish languages; e) research that addressed, directly or indirectly, the relationship between climate change and one or more dimensions of Food and Nutrition Security, such as availability, access, biological utilisation of food, food stability, nutritional quality, or population vulnerability. Studies with explicit methodological rigour and scientific relevance to the investigated object were prioritised.

The exclusion criteria involved: a) publications duplicated among the consulted databases; b) simple abstracts, editorials, letters to the editor, opinion essays, and materials without technical review; c) documents without access to the full text; d) studies published outside the established time frame; e) productions that dealt exclusively with climate change without an interface with food and nutrition; f) studies focused only on agricultural economic productivity without relation to food security; and g) articles with methodological inconsistency or insufficiency of analytical data.

The process of selecting the studies occurred in three successive stages: identification, screening, and eligibility. Initially, the reading of the titles was carried out to exclude manifestly irrelevant studies; subsequently, the analysis of the abstracts of the potentially eligible works was conducted; finally, the full reading of the selected publications was carried out, confirming their adherence to the established criteria and to the objective of the review.

After the final selection, the included studies were organised in a standardised extraction instrument containing: authorship, year of publication, country or place of the study, objective, methodological design, main results, and conclusions. The analysis of the data was conducted through thematic content analysis, enabling the identification of recurrent patterns, convergences, and gaps in the literature. The evidence was grouped into analytical categories, such as: climate impacts on food production and supply; economic repercussions on food access; social inequalities and vulnerabilities; nutritional and health effects; and public policies of mitigation and adaptation (Bardin, 2016).

This methodological path confers greater scientific rigour, transparency, and interpretative robustness to the results, allowing an understanding of the current state of knowledge about the impacts of climate change on Food and Nutrition Security and supporting future research, public policies, and intersectoral strategies aimed at promoting health and sustainability.

4 RESULTS / DISCUSSION

The analysis of the reviewed literature evidenced scientific consensus that climate change is configured as one of the main factors of instability of contemporary food systems. The progressive increase in global average temperature, associated with the irregularity of rainfall regimes and the intensification of extreme events, such as droughts, floods, and heatwaves, has compromised agricultural productive capacity in different regions of the world. Such transformations directly affect food availability and increase the risk of food insecurity, especially in low- and middle-income countries, whose adaptive capacity tends to be more limited (IPCC, 2023; Wheeler; Von Braun, 2020).

Within the scope of agricultural and livestock production, it was observed that strategic crops for human food, such as rice, maize, wheat, and legumes, present high sensitivity to climatic changes. Prolonged exposure to water stress, soil degradation, and thermal rise may reduce yield, nutritional quality, and the predictability of harvests. In addition, studies report the geographical expansion of agricultural pests and diseases, aggravating economic losses and pressuring small rural producers, particularly those dependent on subsistence agriculture (Bouabdelli *et al.*, 2022; Grigorieva, 2020).

Another aspect widely discussed refers to the economic impacts arising from the reduction in food supply. The literature demonstrates that productive fluctuations associated with extreme weather events contribute to the rise in food prices in the national and international market, compromising the purchasing power of families. This phenomenon affects socially vulnerable groups more intensely, in which a significant portion of income is

already destined for food, favouring quantitative and qualitative restriction of food consumption (Lloyd *et al.*, 2024; Springmann *et al.*, 2021).

In the Brazilian context, the studies indicate that the effects of climate change overlap with historical and structural inequalities. Regions such as the Northeastern Semi-arid, the Legal Amazon, and urban peripheries present greater susceptibility to food insecurity owing to the combination of poverty, infrastructural fragility, low coverage of public policies, and economic dependence on climate-sensitive sectors. Recent data reveal the persistence of worrying levels of moderate and severe food insecurity, reinforcing the need for intersectoral and territorialised governmental responses (Penssan, 2021; Monteiro *et al.*, 2022).

In addition to the quantitative dimension of access to food, the literature highlights significant impacts on the nutritional quality of diets. In scenarios of food inflation and reduced household income, the substitution of fresh and minimally processed foods by ultra-processed products of lower relative cost and higher energy density tends to occur. Such a process simultaneously favours micronutrient deficiencies, overweight, and an increase in the prevalence of chronic non-communicable diseases, characterising the so-called double burden of malnutrition (Fanzo *et al.*, 2022; Myers *et al.*, 2020).

The findings also demonstrate that food insecurity induced by climate events directly repercusses on public health. Interruptions in water supply, damage to logistical infrastructure, post-harvest losses, and food contamination increase population exposure to infectious diseases and nutritional disorders. Thus, food security should be understood as an essential component of health promotion and health surveillance, requiring articulation between environmental, agricultural, and assistance policies (WHO, 2023; Salvajo *et al.*, 2023).

It is important to highlight that the observed impacts are not distributed homogeneously among population groups. Children, the elderly, women in situations of vulnerability, indigenous peoples, traditional communities, and family farmers are among the segments most exposed to the food and health consequences of the climate crisis. This pattern corroborates theoretical models of the social determinants of health, according to which income, educational attainment, territory, and labour insertion condition different levels of protection or exposure to risk (Santos *et al.*, 2023).

In contrast to the identified risks, the literature points out successful experiences related to resilient agriculture and agroecology as promising strategies of climate adaptation. Practices such as crop diversification, sustainable water management, recovery of degraded soils, incentive to biodiversity, and the strengthening of family farming have shown potential to expand local productive security and reduce dependence on long supply chains. Such

initiatives contribute simultaneously to environmental sustainability, income generation, and food sovereignty (Altieri; Nicholls, 2020; FAO, 2021).

In the institutional field, the studies reinforce the relevance of public policies of social protection and food supply. Income transfer programmes, school feeding, governmental purchases from family farming, and the strengthening of the Sistema Nacional de Segurança Alimentar e Nutricional constitute effective mechanisms for mitigating the social impacts of the climate crisis. However, their effectiveness depends on administrative continuity, adequate financing, systematic monitoring, and intersectoral governance among health, agriculture, social assistance, and the environment (Brasil, 2024).

In summary, the analysed results demonstrate that climate change represents a concrete and multifaceted threat to Food and Nutrition Security. It is not exclusively an environmental problem but a systemic crisis that involves agricultural production, economic access, the quality of diets, collective health, and social justice. Confronting this scenario requires evidence-based policies, international cooperation, and a transition to sustainable, resilient, and socially inclusive food systems, in line with the Sustainable Development Goals and the global commitments to climate adaptation (ONU, 2015; FAO *et al.*, 2023; IPCC, 2023).

5 FINAL CONSIDERATIONS

The evidence analysed in this review demonstrates that climate change represents one of the main contemporary challenges for the guarantee of Food and Nutrition Security (FNS), directly impacting the availability, access, utilisation, and stability of food in different regions of the world. Extreme weather events, such as droughts, floods, heatwaves, and changes in precipitation regimes, compromise agricultural production, affect food systems, and widen social inequalities, making vulnerable populations even more susceptible to food and nutrition insecurity.

It was observed that the effects of climate change transcend the environmental dimension, configuring themselves as a complex problem that involves economic, social, and health aspects. The reduction in agricultural productivity, the loss of biodiversity, the increase in food prices, and the greater occurrence of diseases related to water, food, and transmission vectors directly impact the health of populations. In this context, food insecurity ceases to be merely a matter of production and supply, coming to be recognised as an important social determinant of health.

The analysis of the interfaces between health, environment, and society evidences the need for integrated and intersectoral approaches to confront these challenges. Adaptation

and mitigation strategies must simultaneously consider the promotion of health, environmental sustainability, the protection of natural resources, and the reduction of socioeconomic vulnerabilities. The adoption of more resilient, sustainable, and inclusive food systems becomes fundamental to ensure the food security of present and future generations.

The relevance of public policies aimed at sustainable agriculture, environmental conservation, water security, health surveillance, and social protection is also highlighted. The strengthening of climate and food governance, combined with investment in research, technological innovation, and environmental education, can contribute significantly to increasing the adaptive capacity of communities in the face of climate impacts.

From the perspective of Planetary Health, the results reinforce that human health depends directly on the preservation of ecosystems and on climate stability. Thus, confronting climate change is not only an environmental agenda but also an essential strategy for the promotion of health, the reduction of inequalities, and the guarantee of the human right to adequate food.

Finally, this study evidences the need to expand investigations on the impacts of climate change on Food and Nutrition Security, especially in contexts of greater socio-environmental vulnerability, such as the Amazon and other regions strongly dependent on natural resources. The production of robust scientific evidence may support more effective decisions and contribute to the construction of more resilient and sustainable societies, committed to the health of populations and of the planet.

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ULTRASONOGRAPHY IN THE MORPHOPHYSIOLOGICAL ASSESSMENT OF THE BOVINE MAMMARY GLAND: DIAGNOSTIC FOUNDATIONS FOR DAIRY FARMING

ULTRASSONOGRAFIA NA AVALIAÇÃO MORFOFISIOLÓGICA DA GLÂNDULA MAMÁRIA BOVINA: BASES DIAGNÓSTICAS PARA A PECUÁRIA LEITEIRA

ULTRASONOGRAFÍA EN LA EVALUACIÓN MORFOFISIOLÓGICA DE LA GLÂNDULA MAMARIA BOVINA: BASES DIAGNÓSTICAS PARA LA GANADERÍA LECHERA



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ABSTRACT

Brazilian dairy agribusiness occupies a prominent global position, with an annual output exceeding 34 billion litres. However, mastitis and other mammary disorders represent severe economic obstacles, impacting productivity and animal welfare. The aim of this work is to demonstrate the applicability of ultrasonography in the morphophysiological assessment of the bovine mammary gland, establishing new precision diagnostic foundations for modern dairy farming through the integration of classical semiology and high-resolution imaging. The glandular structure, composed of four independent quarters and supported by a complex ligamentous apparatus, demands high metabolic activity for milk synthesis, a process governed by delicate endocrine control and by the neuroendocrine ejection reflex mediated by oxytocin. Systematic clinical examination, which includes anamnesis, inspection, palpation and field tests (Black-Bottomed Strip Cup and CMT), is fundamental but limited in the assessment of hidden internal lesions. In this context, ultrasonography assumes a leading role as a non-invasive and painless precision tool; the use of B-mode allows mapping of tissue echotexture to identify early fibrosis and abscesses, while Colour Doppler monitors perfusion and inflammatory haemodynamic changes before the onset of clinical symptoms, also optimising the study of obstructive teat pathologies through the water-bath immersion technique. It is concluded that technological integration in mammary diagnosis is indispensable for the sustainability of dairy farming, enabling early interventions, effective therapeutic monitoring, preservation of animal welfare and support for genetic selection of more resistant dams.

Keywords: Dairy Cattle Farming. Mastitis. Semiology. Udder. Mammary Ultrasonography.

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RESUMO

O agronegócio leiteiro brasileiro ocupa uma posição de destaque mundial, com uma produção superior a 34 bilhões de litros anuais. Contudo, a mastite e outras afecções mamárias representam entraves econômicos severos, impactando a produtividade e o bem-estar animal. O objetivo deste trabalho é demonstrar a aplicabilidade da ultrassonografia na avaliação morfofisiológica da glândula mamária bovina, estabelecendo novas bases diagnósticas de precisão para a pecuária leiteira moderna por meio da integração entre a semiologia clássica e a imagem de alta resolução. A estrutura glandular, composta por quatro quartos independentes e sustentada por um complexo aparato ligamentar, exige uma demanda metabólica elevada para a síntese láctea, processo regido por um delicado controle endócrino e pelo reflexo neuroendócrino de ejeção mediado pela ocitocina. O exame clínico sistemático, que inclui anamnese, inspeção, palpação e testes de campo (Caneca de Fundo Preto e CMT), é fundamental, porém limitado na avaliação de lesões internas ocultas. Nesse contexto, a ultrassonografia assume papel protagonista como ferramenta de precisão não invasiva e indolor; o uso do modo B permite mapear a ecotextura tecidual para identificar fibroses e abscessos precoces, enquanto o Doppler Colorido monitora a perfusão e as alterações hemodinâmicas inflamatórias antes do surgimento de sintomas clínicos, otimizando também o estudo de patologias obstrutivas do teto pela técnica de imersão em banho-maria. Conclui-se que a integração tecnológica no diagnóstico mamário é indispensável para a sustentabilidade da pecuária leiteira, possibilitando intervenções precoces, monitoramento terapêutico eficaz, preservação do bem-estar animal e suporte à seleção genética para matrizes mais resistentes.

Palavras-chave: Bovinocultura de Leite. Mastite. Semiologia. Úbere. Ultrassonografia Mamária.

RESUMEN

El agronegocio lechero brasileño ocupa una posición destacada a nivel mundial, con una producción superior a 34 mil millones de litros anuales. Sin embargo, la mastitis y otras afecciones mamarias representan obstáculos económicos severos, impactando la productividad y el bienestar animal. El objetivo de este trabajo es demostrar la aplicabilidad de la ultrasonografía en la evaluación morfofisiológica de la glándula mamaria bovina, estableciendo nuevas bases diagnósticas de precisión para la ganadería lechera moderna mediante la integración entre la semiología clásica y la imagen de alta resolución. La estructura glandular, compuesta por cuatro cuartos independientes y sostenida por un complejo aparato ligamentario, exige una demanda metabólica elevada para la síntesis láctea, proceso regido por un delicado control endocrino y por el reflejo neuroendocrino de eyección mediado por la oxitocina. El examen clínico sistemático, que incluye anamnesis, inspección, palpación y pruebas de campo (Taza de Fondo Negro y CMT), es fundamental, pero limitado en la evaluación de lesiones internas ocultas. En este contexto, la ultrasonografía asume un papel protagonista como herramienta de precisión no invasiva e indolora; el uso del modo B permite mapear la ecotextura tisular para identificar fibrosis y abscesos precoces, mientras que el Doppler Color monitorea la perfusión y las alteraciones hemodinámicas inflamatorias antes de la aparición de síntomas clínicos, optimizando también el estudio de patologías obstrutivas del pezón mediante la técnica de inmersión en baño maría. Se concluye que la integración tecnológica en el diagnóstico mamario es indispensable para la sostenibilidad de la ganadería lechera, posibilitando intervenciones precoces, monitoreo terapéutico eficaz, preservación del bienestar animal y apoyo a la selección genética de matrices más resistentes.

Palabras clave: Ganadería de Leche. Mastitis. Semiología. Ubre. Ultrasonografía Mamaria.

1 INTRODUCTION

Brazilian agribusiness plays a crucial and strategic role in the national economy, standing out significantly in the dairy sector, where the country has consolidated its position as the third largest producer in the world. National output exceeds the historic mark of 35.7 billion litres per year, driven by a cattle herd that has reached 238.2 million animals. Given this magnitude, dairy farming has consolidated itself as one of the most dynamic sectors of the national agribusiness. However, the economic sustainability of this activity is intrinsically dependent on the health of the mammary gland, since pathologies such as mastitis have historically represented the greatest productive bottleneck of the activity. The occurrence of mammary disorders results in severe impacts ranging from a drastic reduction in the volume produced to profound alterations in the centesimal composition of milk, generating high expenditure on pharmaceuticals, early culling of high genetic-value dams and impairment of animal welfare. In this scenario of technological intensification, mastery of the clinical examination and a thorough knowledge of udder morphophysiology become indispensable tools for the veterinarian who seeks to ensure the sanitary safety and competitiveness of the dairy chain (IBGE, 2025; MAPA, 2023).

Anatomically, the udder of the bovine female is defined as a highly complex exocrine structure, composed of four individual and entirely independent mammary glands, which consolidate into a single mass firmly attached to the inguinal region of the animal. These functional units are divided into anterior and posterior mammary quarters, internally separated by connective-tissue membranes that prevent direct communication between the parenchyma of each quarter. It is widely documented in the technical literature that the posterior quarters have a greater glandular development than the anterior ones, being responsible for approximately 60% of the gland's total milk production. The support of this glandular mass, which can reach considerable weights in high-production animals, depends on a robust and specialised suspensory apparatus. The median suspensory ligament, of an elastic nature, and the lateral ligaments, of a predominantly fibrous nature, form the structural basis that keeps the udder properly positioned. Failures in this support system, whether of genetic or traumatic origin, can lead to the clinical condition known as "pendulous udder". This factor has a direct correlation with resistance to pathogen entry, since teats very close to the ground are more exposed to contaminating agents in the environment, predisposing the animal to ascending infections and traumas (Leite *et al.*, 2026; Teissier *et al.*, 2019).

As basic guidelines in the cow-side routine, field tests such as the black-bottomed strip cup are fundamental for the identification of clinical mastitis, allowing the immediate visualisation of clots, blood or alterations in milk colour. Complementarily, the California

Mastitis Test (CMT) is the tool of choice for the detection of subclinical mastitis, based on the principle of gelation of leukocyte DNA present in milk when these come into contact with the specific reagent. However, although these methods indicate the presence of an inflammatory process and increased cellularity, they have inherent limitations, as they do not provide details on the extent of internal lesions in the parenchyma or hidden structural alterations in the cisterns. It is at this point that ultrasonography assumes a leading role in modern buiatrics, representing a significant advance as a precision diagnostic tool. There is an evident linear correlation between the increase in milk cellularity and the loss of ultrasonographic homogeneity, validating the use of this non-invasive, painless and radiation-free method to grade the severity of the tissue response and to map, at an early stage, wall contours, increased echogenicity and slight ductal dilations. In addition, the association of pulsed Doppler allows tracking of haemodynamic and vascular disturbances characterised by reduced mean flow velocity and elevated resistance and pulsatility indices, which correlate directly with the activation of molecular biomarkers of the innate immune response, consolidating the real-time monitoring of tissue architecture and perfusion (Abdel-Hamied *et al.*, 2026; Estevam *et al.*, 2025; Fasulkov, 2012; Flöck; Winter, 2006; Leite *et al.*, 2026; Maddison *et al.*, 2023).

The physiology of lactation and the process of milk ejection are governed by a complex and delicate endocrine control that begins as early as the foetal phase and intensifies during the phases of puberty and gestation. Steroid hormones, such as oestrogen and progesterone, act in the development of the duct system and of the secretory parenchyma, respectively. During the lactation period itself, prolactin and somatotropin maintain the metabolic activity of the epithelial cells, while the mechanical process of milk ejection depends on an immediate neuroendocrine reflex. Tactile stimulation of the udder, provoked either by the calf's suckling or by correct pre-milking hygiene, sends afferent signals to the hypothalamus, promoting the rapid release of oxytocin by the neurohypophysis. Oxytocin, upon reaching the mammary gland via the bloodstream, causes the contraction of the myoepithelial cells that surround the alveoli, forcing the milk out into the large ducts. Interruptions in this physiological process, caused by stress, fear or pain, provoke the release of adrenaline. This hormone promotes vasoconstriction and blocks the oxytocin receptors, resulting in severe milk retention and direct damage to milking management and to gland health. This prolonged retention raises the intramammary hydrostatic pressure, which can initiate an early aseptic inflammatory process and weaken the epithelial cellular barriers even before bacterial invasion (Akers, 2016; Maddison *et al.*, 2023; Reece, 2017).

For the maintenance of mammary health, the clinical examination plan must be carried out in a systematic and rigorous manner to avoid diagnostic failures. The protocol is grounded in classical semiology, beginning with a detailed anamnesis, seeking information on the reproductive history, somatic cell count (SCC) of the herd and previous occurrences of clinical mastitis. The physical restraint of the animal is a critical step and must be carried out in a way that ensures the safety of the examiner without causing excessive discomfort to the animal, using restraint chutes or hobbles. Visual inspection at a distance allows assessment of the symmetry of the quarters, the presence of oedemas, abscesses, fistulae or cutaneous lesions on the teats. The subsequent manual palpation is essential to detect alterations in local temperature (hyperthermia in acute cases), painful sensitivity and consistency of the parenchyma. In healthy animals, the glandular tissue should be soft and elastic on palpation; the presence of firm, hardened areas or with nodulations indicates fibrosis processes resulting from chronic or cicatricial inflammations (Dirksen; Gründer; Stöber, 2005; Feitosa, 2014; 2020; Jackson; Cockcroft, 2014).

The relevance of diagnostic imaging takes on fundamental contours when one considers the need for early interventions before irreversible damage occurs to the secretory parenchyma. Although tests based on cellular or biochemical inflammatory biomarkers, such as the CMT and the SCC, are sensitive in pointing out the inflammatory state, they fail to map the internal morphology of the affected organ and cannot detail the degree of hidden structural impairment of the parenchyma. Ultrasonography mitigates this gap by acting directly in the identification of microscopic and macroscopic structural alterations in real time, serving as a refined technique of screening and monitoring on the farm. It is a substantially less invasive and stressful approach for the animal when compared with tissue biopsies or repeated probings of ducts, which frequently cause physical traumas and predispose to the ascension of external pathogens. Being a painless method, ultrasonography acts in accordance with the modern precepts of welfare in dairy production, avoiding acute stress neuroendocrine responses and preserving the physiological homeostasis necessary to maintain lactation productivity (Maddison *et al.*, 2023; Venkatesan *et al.*, 2020).

The application of ultrasonographic technology to the mammary gland uses transducers that emit sound waves at varied frequencies, and the correct choice of equipment is what guarantees the effectiveness of the examination. Low-frequency transducers, such as convex ones of 3.5 to 5 MHz, offer greater penetration of the sound waves, being ideal for scanning the deep glandular parenchyma and visualising the gland cistern. On the other hand, high-frequency linear transducers (7.5 to 10 MHz) provide superior image resolution for superficial structures, being indispensable for the detailed study of the teat, the papillary

canal and the cistern wall. Through the direct-contact technique, the transducer is applied with acoustic gel over the skin of the udder, allowing observation of the echogenicity of the parenchyma. Healthy mammary tissue presents ultrasonographically as a fine and homogeneous granular structure, with the presence of anechoic (black) blood vessels and ducts. Pathological alterations, such as abscesses, are visualised as cavitary structures with content of variable echogenicity, while fibrosis manifests as hyperechoic (white) areas that distort the normal architecture of the organ. In this sense, diagnostic ultrasonography acts as a determining tool to discriminate with precision the severity of these chronic structural parenchymal alterations from acute reversible inflammatory processes, optimising clinical decision-making at the animal's side. In addition, the use of the Doppler tool allows the monitoring of blood flow in real time, assisting in the differentiation between acute inflammatory processes and neoplasias. Doppler mapping quantifies the vascular resistance indices, allowing the clinician to discern areas with active inflammation amenable to therapeutic intervention from those already taken over by irreversible fibrosis, which guides a realistic economic prognosis for the producer (Estevam *et al.*, 2025; Fasulkov, 2012; Flöck; Winter, 2006; Leite *et al.*, 2026; Maddison *et al.*, 2023; Seibt *et al.*, 2023).

The detailing of the vascular architecture by means of Doppler adds an unprecedented layer of precision to the early diagnosis of mastitis, since the tissue perfusion of the udder undergoes measurable alterations immediately after bacterial infection, even before the establishment of severe parenchymal damage. The monitoring of blood flow in the main supply routes of the gland, such as the milk vein and the pudendoepigastric trunk, allows the non-invasive measurement of haemodynamic parameters such as maximum flow velocity and the vascular resistance index. The significant increase in circulating blood volume correlates directly with the recruitment of inflammatory cells in mammary quarters under subclinical infectious stress, allowing the veterinarian to identify haemodynamic alterations early and to act with supportive therapies or preventive management adjustments before the loss of functional secretory tissue (Braun *et al.*, 2017; Maddison *et al.*, 2023).

For a thorough assessment of the anatomy of the teat, where many obstructive pathologies originate, the "water-bath" or immersion technique is widely recommended by specialists. In this modality, the teat is submerged in a container, such as a plastic cup or disposable glove, containing warm water or physiological solution, and the transducer is positioned externally to the container. The water acts as an excellent acoustic coupling medium, eliminating artefacts caused by direct contact and avoiding the compression of the sensitive structures of the teat by the operator's hand. This technique provides a perfect acoustic window for precise biometric measurements, such as the length of the teat canal,

the width of the papillary cistern and the thickness of the mucosal wall. Such measurements are crucial to identify stenoses, internal papillomas or other pathologies that interfere directly with milk drainage, as observed in follow-up studies of affected mammary quarters. In addition, studies indicate that teats with shorter canals or wider sphincters may present greater predisposition to the entry of microorganisms, making ultrasonography a predictive tool for the selection of animals more resistant to infections (Franz *et al.*, 2009; Leite *et al.*, 2026; Tóth *et al.*, 2023).

The application of high-resolution ultrasonography at the papillary extremity also serves as a direct indicator of the localised mechanical stress exerted by the milking machinery. Physical alterations in the thickness of the teat wall and the focal loss of the anechoic zones of the papillary cistern occur due to the development of oedemas induced by failures in the vacuum level or in the pulsation rate of the equipment. The early detection of these hidden structural alterations in the mucosa, which precede the macroscopic lesions and the external cracks in the teat skin, prevents mechanical stress from evolving into severe conditions of clinical mastitis, transforming field ultrasonography into an indispensable tool to audit milking management and to safeguard the productive health of the herd (Gleeson *et al.*, 2004; Maddison *et al.*, 2023).

The rigorous integration of the traditional semiological methods with high-resolution ultrasonographic technology represents the state of the art in the sanitary management of contemporary dairy herds. The capacity to differentiate physiological processes, such as parturition oedemas, from serious infectious processes and to monitor tissue recovery after antibiotic treatments confers upon the veterinarian an unprecedented diagnostic and prognostic assertiveness. The holistic understanding of mammary health, provided by the real-time visualisation of internal structures, raises the standard of monitoring in the field and allows early interventions, especially at subclinical stages. Beyond the immediate clinical aspect, the use of imaging as support for genetic selection allows producers to seek animals with udder and teat conformation that favour productive longevity and milking ease. The continuous investment in technical training for the use of these diagnostic tools therefore proves indispensable to guarantee economic sustainability, food safety and animal welfare, ensuring that early diagnosis is the central pillar of ruminant production in the contemporary global market (Hoque *et al.*, 2024; Leite *et al.*, 2026; Santos *et al.*, 2022).

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ARTIFICIAL INTELLIGENCE, VULNERABILITY AND THE RIGHT TO HEALTH: RISKS OF ALGORITHMIC DISCRIMINATION AND CHALLENGES TO THE LEGAL PROTECTION OF PATIENTS

INTELIGÊNCIA ARTIFICIAL, VULNERABILIDADE E DIREITO À SAÚDE: RISCOS DA DISCRIMINAÇÃO ALGORÍTMICA E DESAFIOS À PROTEÇÃO JURÍDICA DOS PACIENTES

INTELENCIA ARTIFICIAL, VULNERABILIDAD Y DERECHO A LA SALUD: RIESGOS DE LA DISCRIMINACIÓN ALGORÍTMICA Y DESAFÍOS A LA PROTECCIÓN JURÍDICA DE LOS PACIENTES



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ABSTRACT

Considering the increasing incorporation of artificial intelligence into health services and the risks of reproducing inequalities through algorithmic systems, this article analyses the impacts of these technologies on patients in vulnerable situations. It aims to discuss how the use of artificial intelligence in health care may affect the fundamental right to health, health care equity and the legal protection of patients, especially in view of the possibility of algorithmic discrimination. To this end, a qualitative, bibliographic and documentary study is carried out, guided by a legal-critical analysis, based on Brazilian legislation, international documents and scientific studies on artificial intelligence, vulnerability, data protection and fundamental rights. In this way, it is observed that algorithmic systems, when developed from incomplete, biased or poorly representative databases, may reproduce social, racial, economic and territorial inequalities already present in health systems. It is also verified that algorithmic opacity hinders transparency, the contestation of decisions and accountability for possible damages. It is concluded that artificial intelligence will only contribute to the realisation of the right to health if it is subject to governance mechanisms, human supervision, auditing, protection of sensitive data and institutional accountability.

Keywords: Artificial Intelligence. Right To Health. Vulnerability. Algorithmic Discrimination. Legal Protection.

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RESUMO

Considerando a crescente incorporação da inteligência artificial nos serviços de saúde e os riscos de reprodução de desigualdades por meio de sistemas algorítmicos, este artigo analisa os impactos dessas tecnologias sobre pacientes em situação de vulnerabilidade. Objetiva-se discutir de que maneira a utilização da inteligência artificial na assistência à saúde pode afetar o direito fundamental à saúde, a equidade assistencial e a proteção jurídica dos pacientes, especialmente diante da possibilidade de discriminação algorítmica. Para tanto, procede-se a uma pesquisa qualitativa, de natureza bibliográfica e documental, orientada por análise jurídico-crítica, com base em legislação brasileira, documentos internacionais e estudos científicos sobre inteligência artificial, vulnerabilidade, proteção de dados e direitos fundamentais. Desse modo, observa-se que sistemas algorítmicos, quando desenvolvidos a partir de bases de dados incompletas, enviesadas ou pouco representativas, podem reproduzir desigualdades sociais, raciais, econômicas e territoriais já existentes nos sistemas de saúde. Também se verifica que a opacidade algorítmica dificulta a transparência, a contestação de decisões e a responsabilização por eventuais danos. Conclui-se que a inteligência artificial somente poderá contribuir para a efetivação do direito à saúde se for submetida a mecanismos de governança, supervisão humana, auditoria, proteção de dados sensíveis e responsabilização institucional.

Palavras-chave: Inteligência Artificial. Direito À Saúde. Vulnerabilidade. Discriminação Algorítmica. Proteção Jurídica.

RESUMEN

Considerando la creciente incorporación de la inteligencia artificial en los servicios de salud y los riesgos de reproducción de desigualdades por medio de sistemas algorítmicos, este artículo analiza los impactos de estas tecnologías sobre pacientes en situación de vulnerabilidad. Tiene como finalidad discutir de qué manera el uso de la inteligencia artificial en la atención sanitaria puede afectar el derecho fundamental a la salud, la equidad asistencial y la protección jurídica de los pacientes, especialmente ante la posibilidad de discriminación algorítmica. Para ello, se realiza una investigación cualitativa, de carácter bibliográfico y documental, orientada por un análisis jurídico-crítico, con base en la legislación brasileña, documentos internacionales y estudios científicos sobre inteligencia artificial, vulnerabilidad, protección de datos y derechos fundamentales. De esta manera, se observa que los sistemas algorítmicos, cuando se desarrollan a partir de bases de datos incompletas, sesgadas o poco representativas, pueden reproducir desigualdades sociales, raciales, económicas y territoriales ya existentes en los sistemas de salud. También se verifica que la opacidad algorítmica dificulta la transparencia, la impugnación de decisiones y la responsabilización por eventuales daños. Se concluye que la inteligencia artificial solo podrá contribuir a la efectividad del derecho a la salud si se somete a mecanismos de gobernanza, supervisión humana, auditoría, protección de datos sensibles y responsabilidad institucional.

Palabras clave: Inteligencia Artificial. Derecho A La Salud. Vulnerabilidad. Discriminación Algorítmica. Protección Jurídica.

1 INTRODUCTION

Artificial intelligence has been occupying an increasing role in contemporary health systems, influencing diagnostic processes, clinical monitoring, triage, therapeutic planning and the management of services. The advancement of digital technologies, combined with the expanded capacity to process large volumes of data, has enabled the incorporation of algorithmic systems at different stages of care. These tools are frequently presented as instruments capable of increasing diagnostic accuracy, optimising institutional resources and favouring faster clinical decisions. However, their expansion also produces new ethical and legal challenges, especially when their effects fall upon individuals and groups historically rendered vulnerable.

Vulnerability, in the field of health, cannot be understood merely as an individual or biological condition. It is a category traversed by social, economic, racial, territorial, age-related and institutional factors, which directly influence the forms of illness, access to services and the care outcomes achieved by the population. In this sense, the incorporation of artificial intelligence into health services does not occur in a neutral space, since technological systems come to operate in realities already marked by inequalities. The World Health Organization recognises that artificial intelligence has the potential to strengthen health systems, but warns that its use must observe principles of transparency, responsibility, inclusion, equity and the protection of human rights (World Health Organization, 2021).

In Brazil, this discussion assumes even greater relevance in view of the structural inequalities that have historically limited access to health. The Constituição Federal de 1988 recognises health as a right of all and a duty of the State, ensuring universal and equal access to the actions and services aimed at its promotion, protection and recovery (Brasil, 1988). This constitutional mandate underpins the Sistema Único de Saúde and imposes upon the State the duty to develop public policies guided by universality, comprehensiveness and equity. Despite this, barriers persist that disproportionately affect certain population segments, such as black people, the elderly, persons with disabilities, rural populations, traditional peoples and individuals in situations of socio-economic vulnerability.

The incorporation of artificial intelligence systems into this scenario broadens the complexity of the debate. Although such technologies may assist professionals and managers in decision-making, they may also reproduce patterns of exclusion when developed from incomplete, unequal or poorly representative databases. Algorithmic discrimination occurs when automated systems produce outcomes that disadvantage certain groups, even when there is no direct discriminatory intent. Thus, algorithms should not be

understood as purely technical instruments, since the data used for their training may carry historical, social and institutional marks of inequality.

Obermeyer *et al.* (2019), in analysing an algorithm used in the North American health system to identify patients who should receive additional care, demonstrated the presence of significant racial bias. The study found that black patients, when classified with the same risk score as white patients, presented more severe clinical conditions, which indicated the underestimation of their health needs. The problem arose, to a large extent, from the use of care costs as proxies for clinical needs, disregarding the fact that racialised groups, owing to historical inequalities of access, may generate lower health expenditure without this representing a lesser need for care.

Concern with these effects also appears in international documents aimed at the ethical governance of artificial intelligence. The Recommendation on the Ethics of Artificial Intelligence by UNESCO establishes that the development and use of algorithmic systems must be guided by the protection of human dignity, human rights, diversity, social justice and non-discrimination. The document also highlights the importance of transparency, human supervision and accountability, especially when automated decisions may affect people's rights, safety or living conditions (Unesco, 2021).

In the field of health, these concerns become even more sensitive because decisions supported by artificial intelligence may influence diagnoses, referrals, care priorities, treatment recommendations and access to specialised programmes. When the functioning of these systems is not comprehensible to professionals, patients and institutions, the problem of algorithmic opacity arises, frequently described as a “black box”. This opacity hinders the identification of errors, the contestation of decisions and the attribution of responsibility in the event of damages. For Floridi *et al.* (2018), a socially appropriate artificial intelligence must be guided by principles such as beneficence, non-maleficence, autonomy, justice and explicability, so that its use does not remove human and institutional responsibility.

The legal protection of patients also requires attention to the processing of sensitive personal data. The Lei Geral de Proteção de Dados Pessoais, Lei nº 13.709/2018, establishes rules for the processing of personal data in physical and digital media, with the aim of protecting the fundamental rights of freedom, privacy and the free development of personality. Within the same legal instrument, data relating to health are recognised as sensitive personal data, requiring greater caution regarding their collection, storage, sharing and use by public and private institutions (Brasil, 2018).

Nevertheless, data protection, although indispensable, does not exhaust the legal challenges posed by artificial intelligence in health. The use of algorithmic systems also

involves questions related to equality, care equity, patient autonomy, informed consent, the transparency of clinical decisions and accountability for possible damages. In contexts of vulnerability, these problems become more serious, since patients with less access to information, less power of institutional contestation or belonging to historically discriminated groups may be more affected by unjust or insufficiently transparent automated decisions.

The relevance of this study arises from the need to understand the legal and social impacts of artificial intelligence upon vulnerable patients in a context of increasing digitalisation of health care. Although studies on artificial intelligence have expanded in recent years, it is still necessary to deepen the analysis of its relationship with the fundamental right to health, algorithmic discrimination and the legal protection of patients, especially from the Brazilian reality, marked by persistent social inequalities.

In view of this scenario, the present article seeks to answer the following research question: in what way can the use of artificial intelligence systems in health care impact the legal protection of vulnerable patients, especially with regard to the right to health, care equity and the risks of algorithmic discrimination?

The general objective of this study is to analyse the impacts of the use of artificial intelligence in health care upon vulnerable patients, discussing the risks of algorithmic discrimination and the challenges related to the legal protection of these individuals. Specifically, it intends to examine the relationship between vulnerability and the right to health; to identify the main risks associated with algorithmic biases in medical care; and to discuss the legal mechanisms aimed at the protection of patients in view of the increasing incorporation of intelligent systems into health services.

2 THEORETICAL BACKGROUND

The theoretical framework of this study is organised around four central axes: the understanding of health as a fundamental right; the notion of vulnerability in the health field; the incorporation of artificial intelligence into health services; and the risks of algorithmic discrimination in view of the legal protection of patients. This articulation is necessary because artificial intelligence, although frequently presented as a technical instrument for the improvement of care, operates within social systems marked by historical, institutional and territorial inequalities.

2.1 RIGHT TO HEALTH, VULNERABILITY AND CARE INEQUALITIES

The right to health, in the Brazilian legal order, has a fundamental nature and finds direct grounding in the dignity of the human person, in material equality and in social

protection. The Constituição Federal de 1988 established that health is a right of all and a duty of the State, to be guaranteed through social and economic policies aimed at reducing the risk of disease and at universal and equal access to actions and services of promotion, protection and recovery (Brasil, 1988). This constitutional recognition represented a break with restrictive models of care, in which access to health services depended on formal linkage to employment or on the economic capacity of the individual.

The creation of the Sistema Único de Saúde consolidated this change by establishing a public policy guided by the principles of universality, comprehensiveness and equity. The Lei nº 8.080/1990 broadened the legal and social understanding of health by recognising that its levels are determined by factors such as food, housing, basic sanitation, the environment, work, income, education, transport, leisure and access to essential goods and services (Brasil, 1990). In this way, health cannot be reduced to medical or hospital care, since it involves concrete conditions of existence that directly influence the forms of illness, care and survival of the population.

In this scenario, vulnerability assumes a central role in understanding care inequalities. In the health field, it should not be understood merely as individual, biological or clinical fragility, but as a result of social processes that render certain individuals more exposed to illness and less protected by institutions. Black people, the elderly, persons with disabilities, rural populations, traditional peoples, women, children and individuals in situations of poverty face more intense barriers to accessing services, obtaining timely diagnosis, understanding health information and receiving adequate treatment.

Ayres *et al.* (2003) understand vulnerability from three articulated dimensions: individual, social and programmatic. The individual dimension refers to the conditions of information, risk perception and the concrete possibility of action of individuals. The social dimension involves economic, racial, territorial, cultural, educational and gender inequalities. The programmatic dimension, in turn, relates to the capacity of public policies, services and institutions to respond to the needs of the population. This formulation is important because it shifts the analysis of vulnerability from the individual to the set of social and institutional relations that produce a lack of protection.

Vulnerability, therefore, lies not only in the patient, but also in the way the health system organises its responses. An individual may be considered rendered vulnerable not because of a natural condition, but because they encounter material, informational, territorial and institutional barriers that hinder the exercise of their rights. This perspective prevents responsibility for the lack of access to care from being attributed exclusively to the individual,

since it demonstrates that health inequalities arise from social structures that distribute opportunities for protection, diagnosis and treatment unequally.

Recent studies on access to health in Brazil demonstrate that racial and income inequalities remain structuring elements of the population's health experience. Tomasiello *et al.* (2023) point out that the spatial distribution of health services reveals important inequalities, especially when the relationships between race, income and access to care facilities are observed. In areas with a higher proportion of black population and lower income, access conditions tend to be more limited, revealing that physical distance, transport, income and the territorial organisation of services interfere directly with the realisation of the right to health.

The racial question also occupies a relevant place in this debate. The Ministério da Saúde has recognised that racial and social inequalities negatively impact the health of the black population, resulting in higher morbidity and mortality and greater difficulties in accessing services (Brasil, 2025). This recognition reinforces that racism must be understood as a social determinant of health, since it affects living conditions, the treatment received in institutions, the production of epidemiological data and the formulation of public policies. Thus, equity in the SUS requires not only the formal provision of services, but the adoption of specific strategies to confront historically produced inequalities.

The discussion on vulnerability also becomes more complex in view of the digitalisation of health services. The expansion of digital platforms, electronic medical records, teleconsultation, automated triage systems and tools based on artificial intelligence may bring important gains for management and care. However, these technologies are incorporated into a society marked by inequalities in access to the internet, to information, to schooling, to income and to health services themselves. Therefore, technological innovation cannot be presumed to be universally beneficial, since its effects depend on the concrete conditions of access and use by different social groups.

Dankwa-Mullan (2024) warns that the use of artificial intelligence in public health and medicine must be accompanied by ethical reflection aimed at equity, since algorithmic systems may reproduce or amplify inequalities when trained with incomplete, biased or poorly representative data. This concern is especially relevant in unequal countries, in which certain groups appear insufficiently in databases or are historically underdiagnosed and undertreated. In these cases, artificial intelligence may transform prior inequalities into automated criteria for decision-making.

The Organisation for Economic Co-operation and Development also highlights that artificial intelligence presents great potential to improve health outcomes, but involves

significant risks when used without adequate governance, especially in relation to biases, data quality, security, transparency and institutional accountability (OECD, 2024). In the same sense, the World Health Organization has argued that the use of algorithmic technologies in health must observe principles of equity, inclusion, human supervision and the protection of fundamental rights, especially when applied to groups in situations of vulnerability (World Health Organization, 2025).

The incorporation of artificial intelligence into health services must be analysed from this reality. When digital systems are implemented in contexts marked by care inequalities, there is the risk that the technology may not only reproduce these asymmetries, but also render them less visible and more difficult to contest. An algorithm may classify risks, indicate priorities or guide referrals with the appearance of neutrality, but its results depend on the data used, on the criteria defined and on the social conditions that structure the health system itself.

Thus, the promise of technological innovation must be confronted with the legal protection of vulnerable patients. The right to health requires that artificial intelligence be used as an instrument for the expansion of care, and not as a mechanism of exclusion, invisibilisation or indirect discrimination. Equity, in this context, must guide both the formulation of public policies and the development, validation, auditing and use of algorithmic systems in care. Without this concern, technology runs the risk of reinforcing historical inequalities under the appearance of technical efficiency.

2.2 ARTIFICIAL INTELLIGENCE APPLIED TO HEALTH

Artificial intelligence may be understood as a set of computational techniques aimed at performing tasks that, traditionally, would require some degree of human intelligence, such as pattern recognition, information classification, risk prediction and decision support. In the area of health, these technologies have been used in imaging examinations, patient triage, analysis of medical records, prediction of clinical deterioration, hospital management, drug development and the remote monitoring of chronic conditions.

The World Health Organization recognises that artificial intelligence may contribute to the strengthening of health systems, especially by broadening the capacity for data analysis, supporting clinical decisions and favouring prevention strategies. However, the same document warns that its use must be guided by ethical principles, human rights, transparency, responsibility, inclusion and equity, since poorly designed systems may compromise patient safety and deepen already existing inequalities (World Health Organization, 2021).

In the health field, artificial intelligence does not act in isolation. It depends on databases, programming criteria, institutional choices and validation models. Therefore, its apparent neutrality needs to be problematised. Algorithms are constructed from data produced in concrete social contexts. If these data reflect historical inequalities in access to health, underreporting, late diagnoses or a lesser presence of certain groups in services, the system may reproduce these distortions in its recommendations.

Floridi *et al.* (2018) argue that artificial intelligence must be guided by principles such as beneficence, non-maleficence, autonomy, justice and explicability. These principles are especially relevant in health, since automated decisions may directly affect the life, treatment, autonomy and safety of patients. In this way, the use of intelligent systems cannot remove human, medical and institutional responsibility, under penalty of transforming the technology into an opaque and scarcely contestable decision-making instance.

The discussion becomes even more sensitive when one observes that, in many cases, health professionals and patients themselves do not fully understand the criteria used by algorithmic systems. This problem is known as algorithmic opacity or the “black box”, an expression used to indicate situations in which the internal functioning of the system is not transparent or intelligible. In the area of health, this opacity hinders the contestation of decisions, the identification of errors and accountability for damages.

2.3 ALGORITHMIC DISCRIMINATION AND THE REPRODUCTION OF INEQUALITIES

Algorithmic discrimination occurs when automated systems produce outcomes that disadvantage certain social groups, even when there is no explicit discriminatory intent on the part of the developers or users of the technology. This phenomenon may arise from incomplete databases, inadequate classification criteria, apparently neutral variables that function as indirect markers of race, gender, income or territory, in addition to the absence of effective auditing and human supervision.

The study by Obermeyer *et al.* (2019) became one of the main references on the subject by demonstrating the existence of racial bias in an algorithm used in the North American health system. The research identified that black patients, even presenting greater clinical severity, were classified by the system as having a lesser need for specialised care when compared to white patients with the same risk score. The problem was related to the use of care cost as an indicator of medical need, disregarding the fact that historically discriminated populations tend to access fewer services and, consequently, to generate lower health expenditure.

This example reveals that algorithmic discrimination arises not only from technical failures, but from methodological choices that may reproduce social inequalities. By using costs, frequency of care or history of service use as indicators of clinical need, the algorithm may transform inequalities of access into apparently objective criteria. Thereby, individuals who have already been historically excluded from health services may continue to be underestimated by automated systems.

The Recommendation on the Ethics of Artificial Intelligence by UNESCO highlights that algorithmic systems must be developed and used with respect for human dignity, human rights, diversity, social justice and non-discrimination. The document also emphasises the importance of human supervision, transparency and accountability, especially when these technologies are applied in sensitive areas, such as health, security, education and access to fundamental rights (Unesco, 2021).

In the case of vulnerable patients, the risks are amplified. Depending on the way the systems are constructed, poor, black, elderly people, persons with disabilities or residents of territories with low care coverage may be inadequately classified. This may affect diagnoses, referrals, prioritisation in queues, access to treatments and inclusion in monitoring programmes. Thus, algorithmic discrimination comes to constitute not only a technological problem, but also a legal, ethical and political one.

2.4 LEGAL PROTECTION OF PATIENTS IN VIEW OF ARTIFICIAL INTELLIGENCE

The legal protection of patients in view of artificial intelligence must be understood from a set of fundamental rights. The first of these is the right to health itself, which requires universal, equal and safe access to services. The right to equality, to non-discrimination, to privacy, to the protection of personal data, to adequate information, to free and informed consent and to reparation for damages eventually suffered also stand out.

The Lei Geral de Proteção de Dados Pessoais establishes that data relating to health are sensitive personal data, requiring greater rigour in their processing. This provision is relevant because artificial intelligence systems depend on large volumes of data for training, validation and operation. However, the collection and use of this information cannot occur without limits, since it involves intimate aspects of the patients' lives and may generate discrimination when used inadequately (Brasil, 2018).

Data protection, however, is not sufficient to confront all the risks of artificial intelligence in health. Algorithmic discrimination may occur even when data are processed in a formally regular manner. Therefore, the legal protection of patients must also involve mechanisms of transparency, auditing, explicability, human supervision, impact assessment and institutional

accountability. Technology needs to be controlled by legal and ethical parameters capable of preventing automated decisions from uncritically replacing human analysis and the duty of care.

Another relevant point concerns patient autonomy. In a context of increasing use of intelligent systems, the patient must have the right to be informed about the use of algorithmic technologies in decisions that may affect their diagnosis, treatment or access to services. The absence of adequate information weakens consent and hinders the exercise of contestation. In situations of vulnerability, this informational asymmetry may be even more serious, since certain patients have less institutional capacity to question technical decisions or to demand a review of procedures.

In this way, the legal protection of patients requires an integrated approach. It is not enough to recognise the potential of artificial intelligence to improve health care. It is necessary to establish limits, duties and responsibilities so that its use does not compromise fundamental rights. Technology must be an instrument for the expansion of care, and not a mechanism for the silent reproduction of inequalities. The contemporary legal challenge lies precisely in constructing forms of governance that allow innovation without removing the centrality of the human person, equity and social justice.

3 METHODOLOGY

The study was developed from a qualitative approach, with a bibliographic and documentary survey, guided by a legal-critical analysis. The choice of this path arises from the very nature of the investigated object, since the impacts of artificial intelligence in health cannot be understood merely as a technical phenomenon, but as a social, ethical and legal question, especially when its effects fall upon patients in situations of vulnerability.

The analysis was constructed from academic works, scientific articles, Brazilian legislation and national and international institutional documents related to the right to health, vulnerability, artificial intelligence, algorithmic discrimination, the protection of personal data and legal responsibility. In particular, the Constituição Federal de 1988, the Lei nº 8.080/1990, the Lei Geral de Proteção de Dados Pessoais, Lei nº 13.709/2018, as well as documents produced by bodies such as the World Health Organization and UNESCO, were considered.

The qualitative approach allows the problem to be examined in its complexity, considering the social and institutional meanings that traverse the incorporation of digital technologies into health services. According to Minayo (2014), this type of investigation is appropriate when one intends to understand phenomena that involve social relations, values, institutional practices and processes that cannot be reduced to numerical measurement. In

this sense, the study does not seek to quantify the impacts of artificial intelligence, but to understand how algorithmic systems may interfere with the realisation of the right to health and with the legal protection of vulnerable patients.

The bibliographic survey made it possible to construct the theoretical framework and to identify the main debates on the subject. Scientific publications discussing artificial intelligence in health, algorithmic biases, care equity, vulnerability, bioethics and technological governance were prioritised. According to Gil (2002), this procedure makes it possible to gather contributions already produced on a given problem, offering a basis for critical analysis and for delimiting the categories used in the study.

The documentary analysis, in turn, was employed to examine legal norms and institutional documents that guide the protection of patients in view of the use of digital technologies. This procedure made it possible to relate the Brazilian normative framework with international recommendations on the ethics and governance of artificial intelligence, especially with regard to transparency, human supervision, non-discrimination and accountability for damages.

To organise the interpretation of the selected material, three analytical axes were defined: a) right to health, vulnerability and care inequalities; b) artificial intelligence applied to health and ethical risks; c) algorithmic discrimination and the legal protection of patients.

From these axes, the aim was to understand how the use of intelligent systems may affect access, the quality of care, the autonomy and the safety of patients. The analysis considered that algorithms are developed and applied in concrete social contexts, often marked by racial, economic, territorial and institutional inequalities. Therefore, the technology was examined not as a neutral instrument, but as a practice embedded in social and legal relations that may produce or reinforce asymmetries.

As for the criteria for selecting the sources, materials with identified authorship, recognised scientific or institutional publication and direct pertinence to the object of the study were used. Texts without an academic basis, opinion publications without grounding, materials without identification of authorship and sources of an encyclopaedic character were excluded. Recent literature was also prioritised whenever possible, owing to the rapid transformation of artificial intelligence technologies and the regulatory debates on the subject.

As it did not involve interviews, questionnaires, field observation or the collection of personal data, there was no need for submission to the Comitê de Ética em Pesquisa. Even so, care related to academic integrity, the adequate indication of the sources consulted and respect for the intellectual authorship of the works used was observed.

As a limitation, it is recognised that the study does not empirically examine a specific artificial intelligence system used in health services in Brazil. The analysis concentrates on the theoretical, normative and critical discussion of the problem, offering a basis for future investigations that may assess concrete cases, institutional practices or direct impacts upon groups rendered vulnerable.

In this way, the adopted methodological path makes it possible to analyse artificial intelligence applied to health from its relationship with the fundamental right to health, vulnerability, care equity and the legal mechanisms necessary for the protection of patients in view of the risks of algorithmic discrimination.

4 RESULTS AND DISCUSSION

The analysis carried out demonstrates that artificial intelligence applied to health cannot be understood merely as a technical instrument for the modernisation of services. Although these systems are frequently presented as tools capable of increasing diagnostic accuracy, reducing human failures, optimising resources and supporting clinical decisions, their incorporation occurs in health systems previously marked by social, racial, economic, territorial and institutional inequalities. Therefore, the effects produced by artificial intelligence depend not only on its technological capacity, but also on the databases used, on the development criteria, on the validation mechanisms, on human supervision and on the existence of legal responsibility in the event of damages.

Recent studies point out that artificial intelligence may contribute to patient safety when used appropriately, especially in the detection of clinical anomalies, in diagnostic support, in the prevention of adverse events and in the organisation of care flows. De Micco *et al.* (2025) observe that these technologies may strengthen clinical risk management practices, but emphasise that their integration into health services requires attention to reproducibility, to validation in real environments and to the risks arising from their inadequate use. This finding is relevant because it demonstrates that technological innovation, by itself, does not guarantee improved care. For artificial intelligence to be legally compatible with the right to health, it must be safe, validated, transparent and subject to permanent institutional control.

In the Brazilian legal field, this discussion must be interpreted in the light of the Constituição Federal de 1988, which ensures health as a right of all and a duty of the State, through universal and equal access to the actions and services aimed at promotion, protection and recovery. This means that the adoption of intelligent technologies in health services cannot be guided merely by criteria of administrative efficiency or cost reduction.

Artificial intelligence must contribute to the realisation of the fundamental right to health and not to the creation of new forms of exclusion, especially when applied to vulnerable patients.

The recent literature shows that one of the main risks lies in the reproduction of inequalities through apparently neutral systems. Cross, Choma and Onofrey (2024) indicate that biases in medical artificial intelligence may arise at different phases of the technological process, including the choice of databases, the definition of variables, the training of models, validation and clinical implementation. When certain population groups appear insufficiently in the data used, the performance of the system may be inferior for these individuals, affecting diagnoses, risk predictions and therapeutic recommendations. Thus, algorithmic discrimination does not necessarily depend on discriminatory intent, since it may arise from technical decisions that, although apparently objective, produce unequal effects.

This point is especially important for the Brazilian context. The Sistema Único de Saúde was built upon the principles of universality, comprehensiveness and equity, but operates in a reality traversed by persistent inequalities. Black people, the elderly, persons with disabilities, rural populations, traditional peoples and individuals in situations of poverty may be more harmed by systems trained with incomplete or poorly representative data. When an algorithm is fed by records that reflect underreporting, less access to examinations, late diagnoses or low presence of certain groups in services, it may transform historical inequalities into automated criteria for decision-making.

Algorithmic discrimination, in this sense, assumes legal relevance because it directly affects the principle of material equality. It is not enough for the technology to produce good average results if its performance is inferior for groups rendered vulnerable. The legal assessment of artificial intelligence in health must consider the distribution of its benefits and risks. A system that improves general indicators, but reduces the quality of care for certain groups, does not adequately meet the constitutional duty of universal and equal access. Equity requires that technological innovation also be assessed by its capacity to reduce inequalities, and not merely by its overall efficiency.

The analysis of recent studies also reveals that algorithmic opacity remains a relevant obstacle to the protection of patients. Pham *et al.* (2025) highlight that the use of artificial intelligence in clinical decisions involves challenges related to autonomy, beneficence, non-maleficence, justice, transparency and accountability. These principles have a strong legal dimension, since decisions supported by algorithms may interfere with the life, the body, the privacy, the treatment and the continuity of care of patients. When the criteria used by the system are not comprehensible, it becomes more difficult to identify errors, contest decisions and attribute responsibility for damages.

The so-called “algorithmic black box” produces especially serious effects in the field of health. In a care relationship, the patient already finds themselves in a position of technical and informational vulnerability before professionals and institutions. When an automated system whose criteria are not explained is added to this relationship, the asymmetry becomes even greater. The patient may not know that a decision was influenced by artificial intelligence, may not understand the reasons for the recommendation and may have no concrete means to request a review. This situation compromises the right to information, weakens free and informed consent and hinders protection against discriminatory decisions.

The discussion on transparency should not be reduced to the complete opening of the source code or to the exposure of technical details inaccessible to the patient. In the legal field, explicability needs to be understood as the possibility of presenting comprehensible, sufficient and auditable reasons for decisions that affect rights. Thus, hospitals, clinics, operators, professionals and developers must be able to inform the purpose of the system, the data used, the limits of the tool, the known risks and the mechanisms available for human review. Without these elements, artificial intelligence may become an opaque decision-making instance, weakening patient autonomy and hindering accountability.

The need for human supervision appears recurrently in the analysed studies. Weiner *et al.* (2025) affirm that the integration of artificial intelligence into clinical practice requires strategies capable of confronting problems of justice, transparency, consent, confidentiality, accountability and patient-centred care. The authors highlight that systems developed with poorly representative bases or with opaque modelling processes may weaken trust in care and compromise equity. This finding reinforces that human supervision cannot be merely formal. It needs to be qualified, continuous and accompanied by institutional conditions so that professionals may question automated recommendations.

In the sphere of civil and institutional liability, artificial intelligence introduces relevant challenges. When damage arises from a decision supported by an algorithmic system, it is necessary to understand the participation of different agents: the professional who used the tool, the institution that incorporated it, the supplier who marketed it and the developer who built it. Gaddas *et al.* (2025) observe that hospitals and health providers may face significant legal uncertainties as they promote the integration of artificial intelligence technologies, especially in situations of harm to the patient. This discussion demonstrates that responsibility cannot be shifted to the technology as if it were an autonomous subject, since its use results from human, institutional and economic decisions.

In Brazilian law, although there does not yet exist a specific and complete regime for all damages arising from artificial intelligence in health, the protection of the patient may be

constructed from already existing norms. The Constituição Federal, the Lei nº 8.080/1990, the Lei Geral de Proteção de Dados Pessoais, the Código de Defesa do Consumidor, the Código Civil and professional ethical norms offer bases for discussing the duty of information, the duty of safety, the protection of sensitive data, responsibility for failure in the provision of the service and reparation of damages. However, the complexity of algorithmic systems requires greater regulatory precision, especially as regards auditing, traceability, impact assessment and the identification of those responsible at each stage of the technological cycle.

The protection of sensitive personal data constitutes another central point. The Lei Geral de Proteção de Dados Pessoais recognises data relating to health as sensitive data, imposing greater caution regarding the collection, storage, sharing and processing of this information. However, the analysis demonstrates that data protection, although indispensable, is not sufficient to confront all the risks of artificial intelligence in health. A system may process data in an apparently regular manner and, nevertheless, produce discriminatory decisions, if it has been trained with biased bases or validated without analysis of performance across different population groups.

Therefore, the legal protection of patients must go beyond the dimension of privacy and also reach equality, non-discrimination and care safety. The review by Alderman *et al.* (2025), published in The Lancet Digital Health, points to the need to confront algorithmic bias through transparency, standards for health databases, good governance practices and the participation of different actors in the development and assessment of systems. This perspective reinforces that the quality of data is not merely a technical problem, but also an ethical and legal requirement to prevent the technology from producing selective damages against vulnerable groups.

The international regulatory experience also contributes to the discussion. Mello and Roberts (2024), in analysing new anti-discrimination requirements applicable to health organisations and insurers in the United States, highlight that regulation came to require reasonable efforts to identify whether decision-support tools use protected characteristics as variables and to mitigate risks of discrimination. Although this model does not apply directly to Brazil, it reveals an important trend: institutions that use artificial intelligence in health must assume their own duties of assessment, prevention and mitigation of discrimination.

This point dialogues with the Brazilian reality, since the mere contracting or acquisition of a technological tool cannot remove the responsibility of the institution that uses it. Hospitals, clinics, operators and public services must verify whether the system is adequate to the profile of the population served, whether it was validated for the context in which it will

be applied and whether mechanisms for human review exist. The omission in the assessment of risks may constitute an institutional failure, especially when the harm affects patients in situations of vulnerability. In matters of health, innovation does not eliminate the duty of care; on the contrary, it broadens the need for control, prevention and transparency.

The recent literature has also pointed to the need for professional training for the critical use of these technologies. Cary Jr. *et al.* (2025) highlight that the mitigation of biases in artificial intelligence and machine learning tools requires institutional guidelines and training programmes for the health workforce. This finding is relevant because human supervision will only be effective if professionals understand at least minimally the limits, risks and possibilities of the systems used. Otherwise, the presence of a professional in the decision-making process may function merely as a formal validation of the algorithmic recommendation, without real control over its effects.

Training, however, should not be understood as the exclusive responsibility of professionals. Health institutions also need to create governance flows, technology assessment committees, review protocols, channels for contestation and mechanisms for continuous monitoring. The absence of these structures may turn artificial intelligence into a factor that aggravates vulnerability, especially for patients with less access to information, less capacity for institutional contestation and greater dependence on public or private health services.

The discussion carried out makes it possible to affirm that artificial intelligence may contribute to the improvement of care, but only when subject to consistent legal and ethical parameters. Its use must observe the right to health, the protection of sensitive data, material equality, non-discrimination, patient autonomy, the duty of information, care safety and accountability for damages. When these parameters are neglected, the technology ceases to function as an instrument of care and comes to operate as a silent mechanism of exclusion.

In this way, the results indicate that the main question lies not in accepting or rejecting artificial intelligence in health, but in defining the conditions under which it may be legitimately used. The incorporation of these tools must be accompanied by impact assessment, periodic audits, validation in diverse populations, transparency about limitations, qualified human supervision and accessible mechanisms for contestation. In deeply unequal societies, such as the Brazilian one, technological neutrality must be viewed with caution, since automated systems may reproduce historical inequalities with the appearance of scientific precision. The legal protection of vulnerable patients therefore requires that artificial intelligence be regulated and used from the centrality of the human person, care equity and institutional responsibility.

5 CONCLUSION

The present study aimed to analyse the impacts of the use of artificial intelligence in health care upon patients in situations of vulnerability, with emphasis on the risks of algorithmic discrimination and the challenges related to the legal protection of these individuals. From the bibliographic and documentary analysis carried out, it was found that artificial intelligence has the potential to contribute to the improvement of health services, especially in diagnostic support, in the organisation of care flows, in the prediction of clinical risks and in resource management. However, this potential does not eliminate the legal, ethical and social risks arising from its application in systems marked by structural inequalities.

The research demonstrated that algorithmic systems cannot be understood as neutral instruments. Their recommendations depend on the data used, on the programming criteria, on the validation models and on the institutional conditions in which they are applied. When trained with incomplete, biased or poorly representative bases, these systems may reproduce inequalities already present in society and in health services. In this context, vulnerable patients may be more exposed to inadequate diagnoses, mistaken risk classifications, restriction of access to treatments and less favourable care decisions.

It was also found that algorithmic opacity represents a relevant challenge for the protection of patients. When the criteria used by artificial intelligence systems are not comprehensible or auditable, it becomes more difficult to identify errors, contest decisions and attribute responsibility for possible damages. This situation compromises the right to information, patient autonomy, free and informed consent and care safety itself, especially when the technology influences clinical or administrative decisions of direct impact upon people's lives and health.

On the legal level, it was observed that the protection of sensitive personal data, provided for in the Lei Geral de Proteção de Dados Pessoais, constitutes an indispensable but insufficient element to confront all the risks of artificial intelligence in health. The legal protection of patients also requires mechanisms of transparency, human supervision, auditing, impact assessment, validation in diverse populations and institutional accountability. Thus, the discussion must go beyond the dimension of privacy and reach material equality, non-discrimination, care equity and the duty of care.

It is concluded that artificial intelligence will only be able to contribute to the realisation of the right to health if it is developed and used in a manner compatible with the dignity of the human person, equity and the protection of groups rendered vulnerable. In a reality such as the Brazilian one, marked by profound social, racial, economic and territorial inequalities, the

adoption of intelligent technologies must be accompanied by rigorous legal criteria and permanent institutional control. Otherwise, technological innovation may reinforce historical exclusions under the appearance of neutrality, efficiency and technical precision.

In this way, the study contributes to the legal debate by demonstrating that artificial intelligence applied to health must be analysed not merely as a technological advance, but as a phenomenon capable of directly interfering with the materialisation of fundamental rights. It is recommended that future research deepen the empirical analysis of systems used in health services in Brazil, investigating their concrete impacts upon vulnerable patients, as well as the institutional mechanisms available to prevent biases, repair damages and ensure more transparent, just and humanely supervised decisions.

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FORENSIC GENETICS OF PATERNITY: ADVANCES, CHALLENGES AND FRONTIERS IN DNA ANALYSIS

GENÉTICA FORENSE DA PATERNIDADE: AVANÇOS, DESAFIOS E FRONTEIRAS NA ANÁLISE DE ADN

GENÉTICA FORENSE DE LA PATERNIDAD: AVANCES, DESAFÍOS Y FRONTERAS EN EL ANÁLISIS DE ADN



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ABSTRACT

Paternity studies based on DNA analysis constitute a central pillar of contemporary forensic genetics. The evolution from traditional systems towards multiplex STR platforms, complemented by SNP markers and massively parallel sequencing technologies, has substantially increased the power of discrimination and the resolving capacity in complex filiation scenarios. This chapter presents a comprehensive review of the molecular and genetic foundations underpinning paternity testing, as well as of the principal marker systems used in forensic practice. It also examines advanced statistical models, based on likelihood ratios and Bayesian approaches, which allow an objective and quantitative interpretation of genetic evidence. Furthermore, it addresses the principal challenges in the interpretation of results, including the presence of mutations, consanguinity, alternative kinship scenarios and DNA mixture analysis. Finally, it discusses the recommendations of international bodies, such as the International Society for Forensic Genetics and the Scientific Working Group on DNA Analysis Methods, as well as the emerging trends that are redefining the field, among them the integration of artificial intelligence, the combined use of multiple marker types and the expansion of massively parallel sequencing.

Keywords: Paternity. STR. SNP. Likelihood Ratio. Forensic Genetics.

RESUMO

Os estudos de paternidade baseados em análise de ADN constituem um pilar central da genética forense contemporânea. A evolução desde sistemas tradicionais até plataformas multiplex de STR, complementadas com marcadores SNP e tecnologias de sequenciamento

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massivo, aumentou substancialmente o poder de discriminação e a capacidade de resolução em cenários complexos de filiação. Este capítulo apresenta uma revisão integral dos fundamentos moleculares e genéticos que sustentam os testes de paternidade, bem como dos principais sistemas de marcadores utilizados na prática forense. Analisam-se ainda os modelos estatísticos avançados, baseados em razões de verossimilhança e abordagens bayesianas, que permitem uma interpretação objetiva e quantitativa da evidência genética. Da mesma forma, abordam-se os principais desafios na interpretação de resultados, incluindo a presença de mutações, a consanguinidade, os cenários de parentesco alternativo e a análise de misturas de ADN. Finalmente, discutem-se as recomendações de organismos internacionais, como a International Society for Forensic Genetics e o Scientific Working Group on DNA Analysis Methods, bem como as tendências emergentes que estão a redefinir o campo, entre elas a integração de inteligência artificial, o uso combinado de múltiplos tipos de marcadores e a expansão do sequenciamento massivo.

Palavras-chave: Paternidade. STR. SNP. Likelihood Ratio. Genética Forense.

RESUMEN

Los estudios de paternidad basados en análisis de ADN constituyen un pilar central de la genética forense contemporánea. La evolución desde sistemas tradicionales hacia plataformas multiplex de STR, complementadas con marcadores SNP y tecnologías de secuenciación masiva, ha incrementado de manera sustancial el poder de discriminación y la capacidad de resolución en escenarios complejos de filiación. Este capítulo presenta una revisión integral de los fundamentos moleculares y genéticos que sustentan las pruebas de paternidad, así como de los principales sistemas de marcadores utilizados en la práctica forense. Se analizan además los modelos estadísticos avanzados, basados en razones de verosimilitud y enfoques bayesianos, que permiten una interpretación objetiva y cuantitativa de la evidencia genética. Asimismo, se abordan los principales desafíos en la interpretación de resultados, incluyendo la presencia de mutaciones, la consanguinidad, los escenarios de parentesco alternativo y el análisis de mezclas de ADN. Finalmente, se discuten las recomendaciones de organismos internacionales, como la International Society for Forensic Genetics y el Scientific Working Group on DNA Analysis Methods, así como las tendencias emergentes que están redefiniendo el campo, entre ellas la integración de inteligencia artificial, el uso combinado de múltiples tipos de marcadores y la expansión de la secuenciación masiva.

Palabras clave: Paternidad. STR. SNP. Likelihood Ratio. Genética Forense.

1 INTRODUCTION

The determination of paternity through DNA analysis constitutes one of the most relevant milestones in the evolution of applied genetics and legal medicine. The turning point came with the development of DNA fingerprinting by Alec Jeffreys in 1985, initially based on the analysis of highly polymorphic minisatellite regions, which for the first time allowed individual identification with unprecedented resolution (Jeffreys *et al.*, 1985).

Since then, the discipline has undergone a transition towards more robust, reproducible and standardised systems, with the adoption of Short Tandem Repeats (STR) as the markers of choice standing out. These systems, combined with amplification by polymerase chain reaction (PCR), have allowed the analysis of minimal or degraded samples, considerably broadening the field of application in forensic and clinical contexts (Butler, 2009).

In the contemporary context, forensic genetics is configured as an interdisciplinary science that integrates:

- a) Molecular biology (structure and variability of DNA)
- b) Bayesian statistics (evaluation of evidence through likelihood ratios)
- c) Population genetics (allelic frequencies and genetic structure)
- d) Bioinformatics (automated analysis of genetic profiles)

This comprehensive approach allows quantifiable and reproducible scientific evidence to be provided in legal scenarios, where the interpretation of results must meet rigorous standards of validity, transparency and reproducibility (Jobling & Gill, 2004).

Additionally, the advance of emerging technologies such as massively parallel sequencing (NGS) has introduced a new dimension into filiation studies, allowing the simultaneous analysis of multiple types of genetic markers and the resolution of cases previously considered indeterminable, such as those involving highly degraded samples or complex kinship relationships (van der Gaag *et al.*, 2016).

2 GENETIC AND MOLECULAR FOUNDATIONS

Paternity studies are based on the principles of Mendelian inheritance, according to which each individual inherits one allele from each parent at each autosomal locus. This codominant transmission allows the parental genetic contribution to be traced through direct comparison of genetic profiles.

2.1 GENETIC VARIABILITY AND STR MARKERS

STR (Short Tandem Repeats) are short repetitive sequences of between 5 and 50 repeats depending on the genetic marker analysed (2–7 base pairs), widely distributed throughout the human genome. Their high rate of polymorphism, derived mainly from replication slippage mechanisms, generates great allelic diversity, which makes them highly informative markers for human identification (Ellegren, 2004).

Each STR locus presents multiple alleles defined by the number of repeats, and the combination of multiple independent loci allows high probabilities of coincidence to be reached among related individuals and extremely low probabilities among unrelated individuals.

2.2 MOLECULAR BASES OF INHERITANCE IN PATERNITY STUDIES

In a typical paternity analysis:

- a) The child's genetic profile must be explainable by the combined contribution of the mother and the alleged father
- b) Each allele of the child must correspond to one present in each parent

Incompatibilities at multiple loci allow paternity to be excluded, whereas concordance at all analysed loci supports inclusion, subject to statistical evaluation.

2.3 ASSUMPTIONS OF POPULATION GENETICS

The probabilistic interpretation of results requires the application of population genetics principles, among them:

- a) Hardy-Weinberg equilibrium

It assumes that genotypic frequencies remain constant in the absence of evolutionary forces. This principle allows genotypic probabilities to be estimated from allelic frequencies.

- b) Independence between loci

The STR loci used must be genetically independent (not linked), which allows individual probabilities to be multiplied (product rule).

- c) Representative allelic frequencies

The calculation of probabilities depends on adequate population databases. A lack of representativeness can introduce bias into the estimation of the Likelihood Ratio.

Deviations from these assumptions, such as population structure or consanguinity, require the application of statistical corrections, such as the θ coefficient of David Balding and Richard Nichols (Balding & Nichols, 1994).

2.4 MUTATION AND STABILITY OF STRS

Mutations in STRs occur at a relatively low frequency ($\sim 10^{-3}$ per generation), but they can affect interpretation in paternity studies. These mutations usually involve the gain or loss of a repeat unit.

In cases of incompatibility at a single locus, it is necessary to consider:

- a) Probability of mutation
- b) Evidence at other loci
- c) Adjusted statistical models
- d) Allelic losses

2.5 PROBABILISTIC MODELS AND THE BAYESIAN FRAMEWORK

The evaluation of genetic evidence is carried out by calculating the likelihood ratio (Likelihood Ratio, LR), which compares the probability of the data under two alternative hypotheses. (Figure 1)

This approach is integrated within Bayes' theorem, allowing the posterior probability of paternity to be calculated from:

- a) Genetic evidence (CPI)
- b) Prior probability

The application of this probabilistic framework is essential for the objective and quantitative interpretation of results in forensic genetics (Kling *et al.*, 2014).

Practical example of paternity calculation (expert report type)

A case with mother, child and alleged father is analysed. Three STR loci are studied.
Locus 1: Mother (10,12), Child (10,14), Alleged father (14,15) Locus 2: Mother (8,9), Child (9,11), Alleged father (11,12) Locus 3: Mother (13,14), Child (13,15), Alleged father (15,16)

Calculation of the Paternity Index (PI):

Locus 1: $PI = 1 / \text{frequency}(14) = 1 / 0.1 = 10$ Locus 2: $PI = 1 / \text{frequency}(11) = 1 / 0.2 = 5$ Locus 3: $PI = 1 / \text{frequency}(15) = 1 / 0.1 = 10$

$CPI = 10 \times 5 \times 10 = 500$

Probability of paternity:

$W = (CPI \times 0.5) / (CPI \times 0.5 + 0.5)$ $W = (500 \times 0.5) / (500 \times 0.5 + 0.5) = 0.998$ Probability = 99.8%

Expert interpretation

The results are compatible with paternity. The probability obtained indicates very strong evidence in favour of the alleged father being the biological father, as opposed to the hypothesis that he is not.

Figure 1. LR, kinship trees, Bayesian scenarios

The image corresponds to a composite panel with three advanced forensic genetics diagrams (A, B and C) that illustrate key concepts in paternity studies:

A) Likelihood Ratio (LR) graph

This panel shows how the likelihood ratio (LR) evolves as a function of the number of STR loci analysed.

- a) X axis: number of STR loci
- b) Y axis: value of the LR on a logarithmic scale
- c) Blue line (H1): hypothesis that the alleged father is the biological father
- d) Red line (H2): hypothesis that an unrelated individual is the father

It is observed that:

- a) As the number of loci increases, the LR grows exponentially
- b) A marked point (≈ 10 loci) shows an LR of 10,000
- c) Interpretation zones are delimited:
- d) Evidence in favour of H1 (paternity)
- e) Evidence in favour of H2 (non-paternity)

This graph illustrates how the discriminatory power increases with more genetic markers.

B) Genealogical tree (pedigree)

It represents a complex kinship scenario:

- a) Upper part: grandparents (grandfather and grandmother)
- b) Second generation: Alleged father (with question mark); Brother of the alleged father
- c) Third generation: Mother; Child (individual under study); Another descendant (grandchild)

Characteristics:

- a) Use of standard symbols: Squares = men; Circles = women
- b) The "?" sign indicates uncertainty in the filiation

This type of diagram is used to evaluate alternative hypotheses (e.g. the brother could be the biological father).

C) Bayesian decision tree

It shows the logical structure of probabilistic analysis in paternity:

- a) Two hypotheses are posed: H1: alleged father is the father (prior = 0.5); H2: unrelated individual is the father (prior = 0.5)

Each hypothesis is divided into:

- a) Compatible genotype
- b) Incompatible genotype

Then conditional probabilities are assigned:

- a) $P(D|H1)$
- b) $P(D|H2)$

Finally, the formula for the probability of paternity is presented:

$$W = \frac{CPI \times prior}{(CPI \times prior) + (1 - prior)} \quad (1)$$

This scheme summarises how the genetic evidence (CPI) is integrated with prior probabilities within a Bayesian framework.

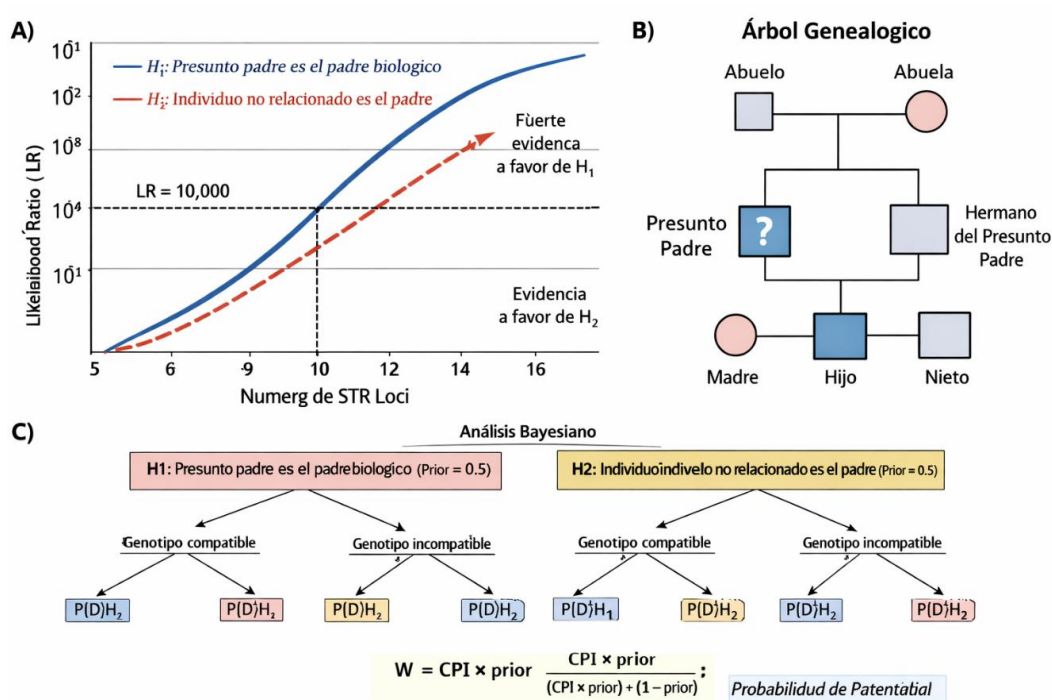
Global interpretation

The figure integrates three key levels of analysis in forensic genetics:

- a) Quantitative (LR) → measures the strength of the evidence
- b) Genealogical (pedigree) → defines possible biological relationships
- c) Probabilistic (Bayes) → integrates evidence and context

Figure 1

A. Likelihood Ratio as a function of the number of STR loci. Relationship between the number of STR loci analysed and the value of the Likelihood Ratio (LR) on a logarithmic scale. Increasing the number of genetic markers exponentially increases the strength of the evidence in favour of the paternity hypothesis. B. Pedigree in a complex kinship scenario. Genealogical diagram illustrating a filiation scenario with alternative hypotheses, including the possibility of collateral kinship (brother of the alleged father). Standard forensic genetics symbols are used. C. Bayesian model in paternity studies. Bayesian decision tree showing the evaluation of hypotheses (H1 and H2) as a function of genetic compatibility, integrating conditional probabilities for the calculation of the probability of paternity



3 MARKER SYSTEMS IN FORENSIC GENETICS

The selection of genetic markers constitutes a critical element in paternity and kinship studies. Current systems combine highly polymorphic markers, with well-characterised inheritance and predictable statistical behaviour. The contemporary trend is oriented towards integrated approaches that combine STR, SNP and sequence information through high-throughput platforms.

3.1 AUTOSOMAL STRS

Autosomal Short Tandem Repeats (STR) represent the reference standard in forensic genetics due to their high power of discrimination, analytical robustness and compatibility with

international databases. These markers consist of tandem repeats of short sequences (2–6 bp), whose variability in the number of repeats generates multiple alleles per locus.

Current commercial systems (for example, GlobalFiler™ or PowerPlex® Fusion) include more than 24 STR loci, many of them integrated into the expanded panels of the CODIS system. The combination of multiple independent loci allows extremely low probabilities of coincidence to be reached ($<10^{-15}$), which is fundamental in contexts of individual identification and paternity (Butler, 2009).

From the technical point of view, STRs present key characteristics:

- a) High heterozygosity (>0.7 at many loci).
- b) Efficient amplification by multiplex PCR.
- c) Compatibility with capillary electrophoresis and multichannel fluorescence.
- d) Interpretation based on peak patterns (electropherograms) (Figure 3).

Nevertheless, they present inherent limitations, such as the appearance of artefacts (stutter), allelic drop-out in degraded samples and relatively frequent mutations ($\sim 10^{-3}$), which must be considered in expert interpretation (Ellegren, 2004; DOI: 10.1038/nrg1348).

3.2 Y-STR AND X-STR

Y-STR (Y chromosome)

STR markers of the Y chromosome are inherited in a strictly paternal manner without significant recombination (except in pseudoautosomal regions). This allows complete male lineages to be analysed through haplotypes.

Main applications:

- a) Cases in which the alleged father is not available
- b) Analysis of sexual assaults with male-female mixtures
- c) Paternal lineage studies

However, the absence of recombination implies that individuals related through the paternal line share the same haplotype, which limits their power of individual discrimination (Kayser, 2017).

X-STR (X chromosome)

Markers of the X chromosome present particular patterns of inheritance:

- a) Males are hemizygous (a single allele)
- b) Females present two alleles with recombination

This makes them especially useful tools in:

- a) Filiation cases involving daughters
- b) Reconstruction of kinship in the absence of the father

c) Evaluation of complex relationships (grandparenthood, maternal uncles)

The analysis of X-STR requires specific statistical models that consider partial linkage and recombination, which increases its interpretative complexity.

3.3 FORENSIC SNPS

Single Nucleotide Polymorphisms (SNPs) represent point variations in the genome and constitute an alternative to or complement of STRs in forensic genetics.

Main advantages:

- a) Short amplicons (<100 bp), ideal for degraded DNA
- b) Low mutation rate ($\sim 10^{-8}$), which improves intergenerational stability
- c) High genomic density (millions of SNPs available)

Limitations:

- a) Lower individual polymorphism (generally biallelic)
- b) They require a larger number of markers to reach discriminatory power comparable to STR
- c) Moderate cost

SNPs are used in:

- a) Analysis of distant kinship
- b) Identification in highly degraded samples
- c) Inference of biogeographical ancestry

The use of high-density SNP panels, together with Bayesian models, allows kinship relationships beyond the first degree to be evaluated (Phillips, 2015).

3.4 MASSIVELY PARALLEL SEQUENCING (NGS/MPS)

Next-Generation Sequencing (NGS) or Massively Parallel Sequencing (MPS) technologies represent a paradigmatic transformation in forensic genetics.

Unlike capillary electrophoresis, which only detects the length of fragments, NGS allows the complete sequence of DNA to be analysed, which provides multiple advantages:

Key advantages:

- a) Identification of isoalleles (same size, different sequence)
- b) Greater power of discrimination at STR loci
- c) Simultaneous analysis of STR, SNP, InDels and mitochondrial DNA
- d) Better resolution in complex mixtures

Advanced applications:

- a) Resolution of complex kinship cases

- b) Differentiation of related individuals
- c) Analysis of highly degraded samples
- d) Integration with artificial intelligence for interpretation

Current limitations:

- a) High cost
- b) Need for standardisation
- c) Bioinformatic complexity
- d) Forensic validation requirements

Various studies have demonstrated that NGS significantly improves the capacity for discrimination compared with traditional methods, especially when multiple types of markers are combined (van der Gaag *et al.*, 2016).

3.5 INTEGRATED APPROACHES IN MODERN FORENSIC GENETICS

The current trend is the combined use of different marker systems:

- a) Autosomal STR → primary identification
- b) Y-STR / X-STR → specific lineage cases
- c) SNP → degraded samples and distant kinship
- d) NGS → advanced resolution

This multimodal approach allows the robustness of the analysis to be maximised and the interpretation in complex scenarios to be improved, consolidating forensic genetics as a highly integrated and technologically advanced discipline.

3.6 COMPARISON OF MARKER SYSTEMS

In modern forensic practice, the selection of the marker system depends on the type of sample, the biological relationship investigated and the complexity of the case. The following table summarises the key characteristics of the principal systems used. (Table 1)

Table 1

Comparison of STR, SNP and NGS in forensic genetics

Characteristic	Autosomal STR	SNPs	NGS/MPS
Type of marker	Tandem repeats (2–6 bp)	Single nucleotide variation	Complete sequencing
Polymorphism	High (multiallelic)	Low (biallelic)	Very high (includes internal variation)
Power of discrimination	Very high (with 15–25 loci)	Moderate (requires hundreds)	Very high
Amplicon size	100–400 bp	<100 bp	Variable

Main application	Paternity, identification	Degraded DNA, distant kinship	Complex cases
Sensitivity to degradation	Moderate	High (better performance)	Very high
Mutation	Relatively high ($\sim 10^{-3}$)	Very low ($\sim 10^{-8}$)	Variable
Interpretation	Relatively simple	Requires statistical models	Complex (bioinformatics)
Cost	Low–moderate	Moderate	High
Forensic standard	Yes (gold standard)	Complementary	Emerging

Source: prepared by the authors.

3.7 INTEGRATED STR + SNP APPROACH IN COMPLEX CASES

The combination of STR and SNP represents an optimal strategy in scenarios where STRs alone do not provide conclusive evidence, such as in:

- a) Collateral kinship (siblings, uncle–nephew or avuncular)
- b) Degraded DNA
- c) Cases with mutations
- d) Absence of one of the parents

4 ADVANCED PRACTICAL EXAMPLE: COMBINED STR + SNP ANALYSIS

4.1 CONTEXT OF THE CASE

A filiation case is analysed in which:

- a) The mother is not available
- b) The alleged father has a biological brother
- c) There is a suspicion that the defendant or his brother could be the true biological father

Classic scenario of complex alternative hypotheses:

- a) H1: The alleged father is the biological father
- b) H2: The brother of the alleged father is the father

4.2 RESULTS WITH STR (LIMITED)

Fifteen STR loci are analysed:

- a) Complete match at all loci
- b) CPI obtained: 2,500

Preliminary interpretation:

- a) Compatible with paternity
- b) BUT: the brother shares a large genetic proportion → inconclusive evidence

4.3 INCORPORATION OF SNPS

Two hundred independent informative SNPs are analysed.

Results:

- a) Multiple SNPs are identified where: The child shares alleles with the alleged father; But not with the brother

Calculation:

- a) LR based on SNPs: 150

4.4 INTEGRATION OF EVIDENCE (COMBINED MODEL)

Given that the systems are independent:

$$LR_{total} = LR_{STR} \times LR_{SNP} \quad (2)$$

4.5 PROBABILITY OF PATERNITY

$$W = \frac{LR}{LR+1} \quad (3)$$

$$W \approx 0.999997 \quad (4)$$

Probability of paternity = 99.9997%

4.6 EXPERT INTERPRETATION

- a) Analysis based solely on STR in this case does not allow a conclusive result to be obtained in relation to the alleged father or his brother
- b) The incorporation of SNPs significantly increases the power of discrimination
- c) The combined evidence provides extremely strong support in favour of H1

4.7 TECHNICAL DISCUSSION

This case illustrates several key principles of advanced forensic genetics:

1. Limitation of STR in close kinship

First-degree relatives share up to 50% of DNA, which reduces the discriminatory capacity of STRs.

2. Advantage of SNP

SNPs allow:

- a) Greater resolution in complex kinship
- b) Evaluation of finer genetic differences

3. Importance of the Bayesian model

The integration of multiple sources of evidence improves the robustness of the result.

4. Independence of markers

It is fundamental to guarantee that STR and SNP are statistically independent in order to apply the multiplication of LR_s.

5. Conclusion of the section

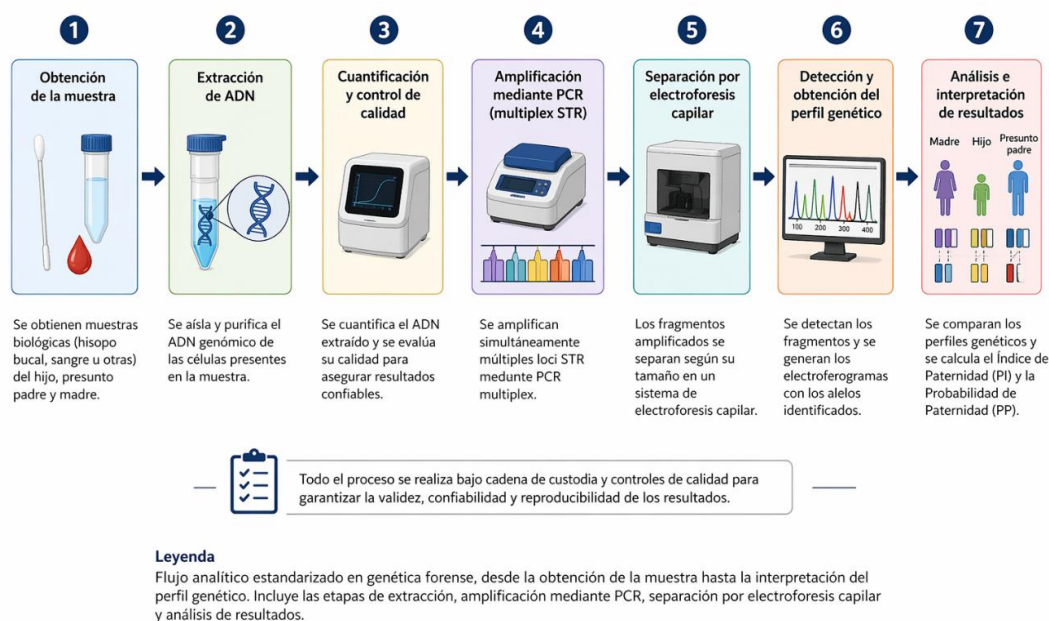
The combined use of STR, SNP and NGS technologies represents the emerging standard in advanced forensic genetics. This approach allows complex scenarios to be addressed with a level of precision significantly superior to that of traditional methods, consolidating a paradigm of multimodal analysis.

5 ANALYTICAL WORKFLOW AND VALIDATION

DNA analysis in forensic genetics follows a highly standardised workflow, designed to guarantee the integrity, traceability and reproducibility of results. This process is divided into pre-analytical, analytical and post-analytical phases, each with specific quality controls. (Figure 2)

Figure 2

Workflow of DNA analysis in paternity studies. Standardised analytical workflow in forensic genetics, from sample collection to interpretation of the genetic profile. It includes the stages of extraction, amplification by PCR, separation by capillary electrophoresis and analysis of results



Source: prepared by the authors.

5.1 PRE-ANALYTICAL PHASE: COLLECTION AND CHAIN OF CUSTODY

Sample collection constitutes a critical point, since any contamination or error in identification can compromise the validity of the analysis.

Key elements:

- Unequivocal identification of individuals
- Complete documentation of the chain of custody
- Use of sterile materials and negative controls
- Adequate conditions of transport and storage

The chain of custody must guarantee the legal continuity of the evidence from its collection to its analysis in the laboratory.

5.2 EXTRACTION AND QUANTIFICATION OF DNA

DNA extraction is carried out by validated methods (silica, magnetic resins or organic extraction), optimised to maximise yield and minimise inhibitors.

Quantification by real-time PCR (qPCR) allows evaluation of:

- Amount of nuclear DNA
- Degradation index

c) Presence of inhibitors

These parameters are essential for deciding the subsequent amplification strategy.

5.3 AMPLIFICATION BY MULTIPLEX PCR

The simultaneous amplification of multiple STR loci by multiplex PCR constitutes the core of the analysis.

Technical considerations:

- a) Optimisation of reaction conditions
- b) Control of artefacts (stutter, pull-up, allelic drop-out)
- c) Inclusion of positive and negative controls

The sensitivity of the system allows minimal amounts of DNA to be analysed (down to the picogram range), which is fundamental in forensic samples.

5.4 SEPARATION AND DETECTION: CAPILLARY ELECTROPHORESIS

The amplified products are separated by capillary electrophoresis and detected by fluorescence.

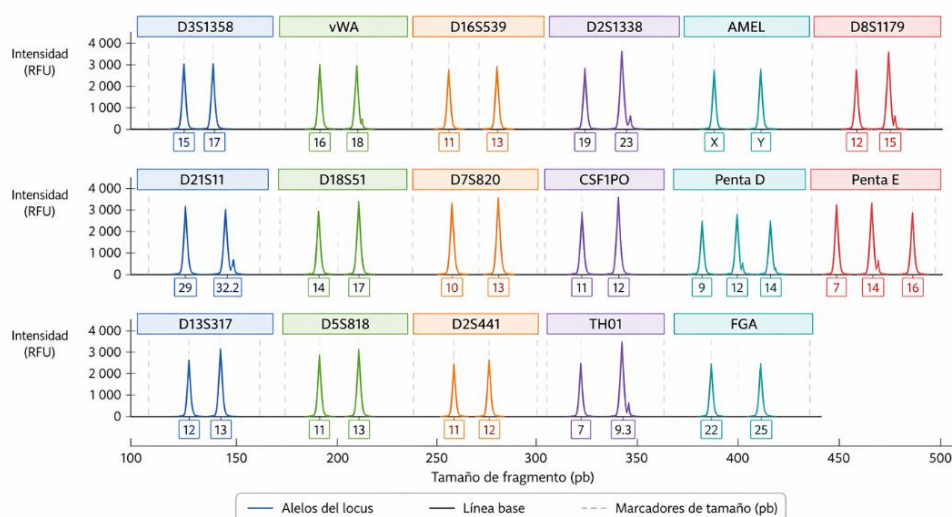
Critical parameters:

- a) Analytical threshold (minimum signal detection)
- b) Stochastic threshold (risk of allelic loss)
- c) Balance of heterozygous peaks

The result is an electropherogram, which represents the genetic profile of the individual.

Figure 3

Representative electropherogram of STR markers. Schematic example of an electropherogram obtained by capillary electrophoresis, showing peaks corresponding to STR alleles. The height of the peaks reflects the intensity of the fluorescent signal and allows interpretation of the genetic profile

**Leyenda**

Ejemplo esquemático de un electroferograma obtenido mediante electroforesis capilar, mostrando picos correspondientes a alelos STR. La altura de los picos refleja la intensidad de señal fluorescente y permite la interpretación del perfil genético. Esta figura ilustra la combinación de múltiples loci STR y el sistema de determinación de sexo (AMEL: X e Y).

Source: prepared by the authors.

5.5 INTERPRETATION OF GENETIC PROFILES

The interpretation requires a critical evaluation of:

- Allelic concordance between individuals
- Presence of artefacts
- Quality of the signal

In complex cases (mixtures, degradation), advanced probabilistic models and specialised software are used.

5.6 VALIDATION AND QUALITY ASSURANCE

The guidelines of the Scientific Working Group on DNA Analysis Methods establish strict criteria for the validation of methods in forensic genetics (SWGDM, 2016).

Validation studies include:

- Sensitivity: minimum limit of detection
- Specificity: capacity to discriminate human DNA
- Reproducibility: intra- and inter-laboratory consistency
- Precision: concordance with expected values
- Robustness: tolerance to experimental variations

In addition, laboratories must comply with quality standards such as ISO/IEC 17025, ensuring technical competence and the traceability of results.

6 ADVANCED STATISTICAL INTERPRETATION

The interpretation of paternity studies is based on a formal probabilistic framework, in which the genetic evidence is evaluated by means of the likelihood ratio (Likelihood Ratio, LR).

6.1 STATEMENT OF HYPOTHESES

In the forensic context, two mutually exclusive hypotheses are established:

- a) H1: the alleged father is the biological father
- b) H2: the biological father is any random individual from the population.

The objective is to evaluate which hypothesis better explains the observed genetic data.

6.2 PATERNITY INDEX (PI)

The paternity index is calculated for each locus as:

$$PI = \frac{P(\text{genotipo del hijo}|H1)}{P(\text{genotipo del hijo}|H2)} \quad (5)$$

This value depends on:

- a) Allelic frequency in the population
- b) Genotype of the alleged father
- c) Genotype of the child (and mother, if available)

6.3 COMBINED PATERNITY INDEX (CPI)

Given that the loci are independent:

$$CPI = \prod PI_i \quad (6)$$

The CPI represents the accumulated strength of the genetic evidence.

6.4 PROBABILITY OF PATERNITY (BAYESIAN MODEL)

$$W = \frac{CPI \cdot prior}{CPI \cdot prior + (1 - prior)} \quad (7)$$

Where:

- a) W = probability of paternity
- b) prior = prior probability (generally 0.5)

This approach integrates genetic evidence with prior information, allowing a quantitative interpretation.

6.5 INTERPRETATION OF THE LIKELIHOOD RATIO

The LR is interpreted in terms of strength of evidence (Table 2):

Table 2

Interpretation of the Likelihood Ratio

LR	Interpretation
<1	Evidence in favour of H2
1–10	Weak evidence
10–100	Moderate evidence
100–10,000	Strong evidence
>10,000	Very strong evidence

Source: prepared by the authors.

This framework is consistent with international recommendations in forensic genetics.

6.6 FACTORS THAT AFFECT INTERPRETATION

- a) Allelic frequencies

The choice of the reference population is critical.

- b) Population substructure

Corrections are applied (θ of Balding-Nichols) to avoid overestimation of the LR.

- c) Mutations

They must be incorporated into the model when there are incompatibilities at one or a few loci.

- d) Dependence between loci

In cases of linked markers (e.g. X-STR), specific models are required.

6.7 ADVANCED MODELS

In complex scenarios the following are used:

- a) Extended Bayesian models
- b) Monte Carlo simulation
- c) Specialised software (Familias, DNA-View)

These approaches allow alternative hypotheses, such as collateral kinship, to be evaluated.

7 COMPLEX SCENARIOS IN PATERNITY STUDIES

In forensic genetics, paternity studies are not always conducted under ideal conditions. Various biological, technical and population factors can introduce ambiguities into the interpretation of genetic profiles. The correct resolution of these scenarios requires the application of advanced probabilistic models, in-depth knowledge of molecular genetics and the use of specialised analytical tools.

7.1 MUTATIONS IN STR

Mutations at STR loci constitute one of the main causes of apparent discrepancies in paternity studies. These occur at an approximate frequency of 10^{-3} per locus per generation and usually involve the gain or loss of a repeat unit, attributed mainly to replication slippage mechanisms.

Forensic implications:

- a) An incompatibility at one or two loci does not necessarily exclude paternity.
- b) The global pattern of the genetic profile must be evaluated.
- c) It is necessary to consider the specific mutation rate per locus.
- d) In these cases it is suggested to increase the number of STRs studied in order to find incompatibilities or not

Interpretative approach:

Models are applied that incorporate mutation probabilities into the calculation of the paternity index (adjusted PI). This allows erroneous exclusions to be avoided in the presence of mutations (Ellegren, 2004).

7.2 ALTERNATIVE KINSHIP

In many cases, the alleged father may have close relatives (siblings, uncles, cousins) who share a significant proportion of their genetic material. This can generate profiles compatible with the child, making discrimination between hypotheses difficult.

Typical scenarios:

- a) Brother of the alleged father as possible progenitor
- b) Paternal uncle
- c) Paternal grandfather

Analytical approach:

- a) Formulation of alternative hypotheses (H1 vs extended H2)
- b) Calculation of specific Likelihood Ratios for each relationship
- c) Use of specialised software (e.g. Familias, DNA-View)

The use of additional markers such as SNP or X-STR can significantly improve the discriminatory capacity in these cases (Kling *et al.*, 2014).

7.3 CONSANGUINITY

Consanguinity introduces genetic dependence between alleles, violating the assumption of independence between loci and affecting the estimation of probabilities.

Main effects:

- a) Increase in the probability of sharing alleles by identity by descent
- b) Overestimation of the Likelihood Ratio if not corrected
- c) Greater complexity in statistical interpretation

Applied corrections:

- a) Use of the θ (theta) coefficient of population structure
- b) Adjustments to allelic frequencies
- c) Bayesian models with inbreeding parameters

The models developed by David Balding and Richard Nichols are widely used for these corrections (Balding & Nichols, 1994).

7.4 DNA MIXTURES

DNA mixtures represent one of the most challenging scenarios in forensic genetics. They occur when the analysed genetic profile contains contributions from two or more individuals.

Main difficulties:

- a) Overlap of alleles
- b) Imbalance in signal intensities
- c) Presence of artefacts

Modern approaches:

- a) Continuous probabilistic models

- b) Analysis based on Likelihood Ratios
- c) Use of specialised software such as: STRmix™; TrueAllele®

These systems allow the probability of contribution of each individual to the mixture to be estimated, improving the objectivity of the analysis (Gill *et al.*, 2012).

7.5 MONOZYGOTIC TWINS

Monozygotic twins share practically 100% of their nuclear DNA, which makes them indistinguishable by conventional STR analysis.

Limitations:

- a) Impossibility of differentiation with standard methods
- b) Complete match in STR and SNP profiles

Advanced strategies:

- a) Next-Generation Sequencing (NGS) to detect somatic mutations
- b) Epigenetic analysis (DNA methylation patterns)
- c) Whole-genome sequencing

These approaches allow minimal differences accumulated after zygotic division to be identified, although their application in routine forensics is still limited (Jobling & Gill, 2004).

7.6 OTHER RELEVANT COMPLEX SCENARIOS

- a) Degraded DNA

Frequent in old forensic samples or those exposed to adverse conditions. It can produce:

- a) Allelic drop-out
- b) Incomplete profiles

SNPs and short amplicons are preferable in these cases.

- b) Absence of one of the parents

It requires:

- a) Genotypic reconstruction
- b) Use of relatives (grandparents, siblings)
- c) Extended kinship models
- c) Multiple mutations or microvariants

They can complicate interpretation if not adequately recognised, especially in automated analyses.

Conclusion of the section:

Complex scenarios represent a central challenge in modern forensic genetics. Their adequate resolution depends on the integration of multiple marker systems, advanced statistical models and specialised bioinformatic tools. The evolution towards multimodal approaches, including STR, SNP and NGS, allows many of the traditional limitations to be overcome, increasing the precision and reliability of paternity studies in real contexts.

7.7 ANALYSIS OF APPLIED CASES IN PATERNITY STUDIES USING STR

In order to complement the theoretical scenarios previously described, applied filiation cases were analysed using autosomal STR markers, evaluating the allelic concordance between the genetic profiles of the child and the alleged father.

This analysis allows the illustration of how the principles of Mendelian inheritance, together with probabilistic models, are applied in real contexts of forensic genetics, including both paternity exclusion and inclusion situations.

a) Cases of paternity exclusion

In a set of analysed cases, multiple allelic incompatibilities were identified at different STR loci, such as D3S1358, D18S51, FGA and D21S11. These discrepancies cannot be explained by normal biological inheritance and, when they occur at more than one independent locus, they constitute conclusive evidence for the exclusion of paternity.

Although point mutations may justify isolated discordances, the presence of multiple simultaneous incongruities rules out this possibility, reinforcing the expert interpretation of non-filiation. (Table 3)

Table 3

Cases of paternity exclusion

Locus	Mother	Child	Alleged father	Compatibility	Interpretation
D3S1358	17,18	16,18	16,16	Not compatible	Exclusion
D18S51	14,17	14,15	10,16	Not compatible	Exclusion
FGA	22,23	25,26	25,26	Partially compatible	Exclusion (multiple loci)

Source: prepared by the authors.

b) Cases of paternity inclusion

In contrast, other cases showed complete concordance at all analysed loci, where each allele of the child is compatible with the genetic contribution of the alleged father (obligatory paternal allele). This pattern is consistent with the inclusion of paternity, although from the forensic point of view it necessarily requires statistical support through the calculation of the Paternity Index (PI) and the Combined Paternity Index (CPI).

These results show how genetic concordance, when evaluated across multiple independent markers, provides a robust basis for inferring biological relationships. (Table 4).

Table 4

Cases of paternity inclusion

Locus	Mother	Child	Alleged father	Compatibility	Interpretation
D3S1358	14,15	14,16	16,18	Compatible	Inclusion
D18S51	12,13	12,17	17,20	Compatible	Inclusion
FGA	22,23	23,24	21,24	Compatible	Inclusion

Source: prepared by the authors.

c) Relevance in complex scenarios

The incorporation of these cases allows contextualisation of the challenges described in this section, particularly in situations where factors such as the following may coexist:

- a) Mutations in STR
- b) Alternative kinship
- c) Limitations in the number of markers

In this sense, although the cases presented correspond to relatively straightforward scenarios (inclusion/exclusion), their analysis reinforces the need to integrate statistical tools and, in complex cases, to complement them with other marker systems such as SNP or NGS.

Taken together, these examples illustrate the practical application of DNA analysis in forensic genetics and its role in well-founded expert decision-making.

8 POPULATION DATABASES

The calculation of the likelihood ratio (Likelihood Ratio, LR) in paternity studies depends critically on the quality, representativeness and adequacy of the population databases used to estimate allelic frequencies. These databases constitute the statistical foundation on which the paternity indices (PI) and the combined index (CPI) are built, so that any bias or error in their selection can significantly affect the final interpretation.

8.1 SELECTION OF REFERENCE POPULATIONS

The choice of an adequate reference population is essential to guarantee valid estimates of allelic frequencies.

Key criteria:

- a) Geographical correspondence with the individuals analysed
- b) Genetic affinity (ethnic origin and ancestry)

- c) Sufficient sample size (generally >200 individuals)
- d) Periodic updating of the database

The use of non-representative populations can lead to an overestimation or underestimation of the LR, affecting the validity of the expert result.

8.2 HARDY-WEINBERG EQUILIBRIUM

Population databases should ideally comply with Hardy-Weinberg equilibrium (HWE), which allows independence between alleles within a locus to be assumed.

Importance:

- a) It allows genotypic probabilities to be calculated from allelic frequencies.
- b) It is a fundamental assumption in the calculation of the PI.

Deviations:

- a) Inbreeding
- b) Natural selection
- c) Population structure

These deviations must be evaluated by statistical tests and, if necessary, corrected.

8.3 POPULATION SUBSTRUCTURE AND θ CORRECTION

Human populations are not genetically homogeneous, which generates substructures that can influence the distribution of allelic frequencies.

To address this problem, the θ (theta) coefficient, developed by David Balding and Richard Nichols, is used.

Function of θ :

- a) Adjust genotypic probabilities
- b) Avoid overestimation of the LR
- c) Introduce a conservative approach into the analysis

Typical values:

- a) $\theta = 0.01$ (large and well-mixed populations)
- b) $\theta = 0.03$ (structured or isolated populations)

8.4 ETHNIC VARIABILITY AND GENETIC DIVERSITY

Genetic variability between human populations is a determining factor in forensic interpretation.

Considerations:

- a) Differences in allelic frequencies between ethnic groups

- b) Influence of migration, genetic admixture and isolation
- c) Importance of regional databases

In Latin American contexts, characterised by high genetic admixture and ethnic variety, it is particularly relevant to consider population heterogeneity in order to avoid biases.

8.5 SIZE AND QUALITY OF DATABASES

The precision of the estimates depends directly on the sample size and the quality of the data.

Requirements:

- a) Adequate size (≥ 200 –500 individuals per population)
- b) Quality control in genotyping
- c) Elimination of inconsistent data
- d) Inter-laboratory validation

Small databases can generate unstable estimates and increase the uncertainty in the calculation of the LR.

8.6 INDEPENDENCE BETWEEN LOCI

The calculation of the CPI assumes independence between the analysed loci. However, this condition may not be fully met in some cases.

Factors that affect independence:

- a) Genetic linkage
- b) Selection of nearby loci
- c) Use of markers of the X or Y chromosome

In these cases, specific statistical models that consider partial dependence must be applied.

8.7 INTERNATIONAL DATABASES

Various initiatives have allowed the standardisation of databases at a global level:

- a) International Society for Forensic Genetics
- b) FBI CODIS
- c) EDNAP

These platforms provide:

- a) Validated allelic frequencies
- b) Comparability between laboratories
- c) Standardisation of markers

8.8 IMPACT OF ERRORS IN ALLELIC FREQUENCIES

Errors in the selection or estimation of allelic frequencies can generate:

- a) Overestimation of the LR → risk of false inclusions
- b) Underestimation of the LR → loss of evidence
- c) Biased interpretations

For this reason, it is fundamental to adopt a conservative and transparent approach in the selection of databases.

8.9 EMERGING TRENDS

The development of new technologies is transforming the use of population databases:

- a) High-density SNP databases
- b) Integration of massive genomic data (big data)
- c) More complex Bayesian models
- d) Use of artificial intelligence for frequency estimation

These innovations will allow the precision of forensic analyses to be improved in the future.

Conclusion of the section

Population databases constitute a fundamental pillar in the statistical interpretation of paternity studies. Their correct selection, validation and application is essential to guarantee reliable and scientifically sound results. The consideration of factors such as population substructure, genetic variability and data quality allows biases to be minimised and the validity of the conclusions in the forensic field to be strengthened.

9 ETHICAL AND LEGAL CONSIDERATIONS

Paternity analysis through DNA, while constituting a highly precise scientific tool, carries ethical, legal and social implications of great relevance. Genetic information is intrinsically sensitive, since it not only identifies an individual but also reveals biological relationships, family backgrounds and, potentially, medical information. For this reason, its handling must be governed by strict principles of bioethics, confidentiality and professional responsibility.

9.1 INFORMED CONSENT

Informed consent is a fundamental requirement in the conduct of paternity studies. It must be:

- a) Free and voluntary, without external coercion

- b) Specific, clearly indicating the purpose of the analysis
- c) Understandable, adapted to the educational level of the individual
- d) Documented, by means of the signature of the participants

Key aspects that must be explained:

- a) Nature of the genetic study
- b) Possible results (inclusion, exclusion, inconclusive)
- c) Technical limitations
- d) Legal and family implications

In the case of minors, consent must be granted by the legal representatives, always respecting the principle of the best interest of the child.

9.2 PROTECTION OF GENETIC DATA AND CONFIDENTIALITY

Genetic data are considered highly sensitive information. Their handling must comply with principles of:

- a) Strict confidentiality
- b) Restricted access to authorised personnel
- c) Secure storage (physical and digital)
- d) Use limited to the authorised purpose

In many legal systems, genetic data are protected by specific personal data protection regulations. The improper use of this information can have significant legal and ethical consequences.

In addition, laboratories must establish clear policies regarding:

- a) Time of storage of samples
- b) Secure elimination of data
- c) Secondary use of the information

9.3 PSYCHOSOCIAL IMPACT

The results of a paternity test can have profound consequences in the lives of individuals and their families.

Possible effects:

- a) Alteration of personal identity
- b) Family conflicts
- c) Legal implications (custody, inheritance)
- d) Emotional and psychological stress
- e) Identity conflicts

For this reason, it is recommended to:

- a) Offer counselling before and after the test
- b) Communicate results in a clear and empathetic manner
- c) Avoid erroneous interpretations of probabilistic results
- d) Deliver a reliable and conclusive result

The adequate communication of the uncertainty and the statistical significance of the results is crucial to prevent misunderstandings.

9.4 LEGAL USE AND PROBATIVE VALUE

In the judicial sphere, paternity studies have a high probative value, but their admissibility depends on:

- a) Compliance with the chain of custody
- b) Validation of the laboratory
- c) Scientifically accepted methodology
- d) Interpretation in accordance with international standards

The expert in forensic genetics must:

- a) Present results in an objective and impartial manner
- b) Clearly explain the meaning of the Likelihood Ratio
- c) Avoid absolute statements (100% certainty)

Genetic evidence must be contextualised within the body of evidence of the judicial process.

9.5 TRANSPARENCY AND INTERPRETATION OF RESULTS

The recommendations of the International Society for Forensic Genetics emphasise the need for:

- a) Transparency in the methods used
- b) Clarity in the presentation of results
- c) Adequate use of probabilistic language
- d) Communication understandable for judges and lawyers

One of the main challenges is to avoid the prosecutor's fallacy, which consists of incorrectly interpreting the genetic probability as absolute certainty.

9.6 REGULATION AND INTERNATIONAL STANDARDS

The practice of forensic genetics is regulated by various international guidelines and standards, among them:

- a) Scientific Working Group on DNA Analysis Methods
- b) International Organization for Standardization (ISO/IEC 17025)
- c) International Society for Forensic Genetics

These bodies establish criteria on:

- a) Validation of methods
- b) Quality control
- c) Statistical interpretation
- d) Reporting of results

Compliance with these standards is essential to guarantee the acceptance of the results in the judicial sphere.

9.7 EMERGING ETHICAL DILEMMAS

Technological advances have generated new ethical challenges:

- a) Use of genetic databases for unforeseen purposes
- b) Analysis without consent (legal or forensic cases)
- c) Indirect genetic identification (familial searching)
- d) Application of artificial intelligence in forensic genetics

These scenarios require a balance between scientific advance and the protection of individual rights.

Conclusion of the section

Ethical and legal considerations are an essential component in paternity studies through DNA. Scientific precision must be accompanied by responsible handling of genetic information, guaranteeing respect for individual rights, transparency in interpretation and adequate communication of results. The strengthening of regulatory frameworks and the ethical training of professionals are fundamental to ensure a fair, reliable and socially responsible forensic practice.

10 EMERGING TRENDS IN FORENSIC GENETICS

Forensic genetics is in a phase of accelerated transformation driven by advances in biotechnology, computational sciences and data analysis. These innovations are redefining the limits of genetic identification, allowing previously unsolvable scenarios to be addressed and significantly increasing the precision, sensitivity and scope of paternity and kinship studies.

10.1 INTEGRATION OF ARTIFICIAL INTELLIGENCE IN THE INTERPRETATION OF GENETIC PROFILES

The incorporation of artificial intelligence (AI) and machine learning algorithms is revolutionising the interpretation of complex genetic data, particularly in the analysis of DNA mixtures.

Main applications:

- a) Probabilistic modelling of contributors in complex mixtures
- b) Automatic classification of genetic profiles
- c) Optimisation of parameters in electropherograms
- d) Reduction of subjective bias in interpretation

Current probabilistic systems (e.g. STRmix™, TrueAllele®) already incorporate elements of advanced computational modelling, and the evolution towards more sophisticated AI will allow:

- a) Real-time analysis
- b) Integration of multiple types of data (STR, SNP, NGS)
- c) Greater inter-laboratory reproducibility

Limitations:

- a) Need for rigorous validation
- b) "Black box" problems (interpretability)
- c) Regulatory requirements

10.2 COMBINED USE OF STR AND SNP

The multimodal approach that integrates STR and SNP has been consolidated as a key strategy in advanced forensic genetics.

Advantages:

- a) Complementarity: STR (high variability) + SNP (high stability)
- b) Greater power of discrimination in complex kinship
- c) Better performance in degraded samples

Applications:

- a) Identification in cases of collateral kinship
- b) Genetic reconstruction in the absence of progenitors
- c) Resolution of ambiguities in traditional analyses

This approach represents a transition towards integrated models of genetic evidence, in which different types of markers contribute jointly to the probabilistic evaluation.

10.3 MASSIVELY PARALLEL SEQUENCING (NGS/MPS) IN FORENSIC GENETICS

Massively parallel sequencing technologies have introduced a paradigmatic change by allowing the simultaneous analysis of multiple regions of the genome with sequence-level resolution.

Key advantages:

- a) Identification of isoalleles in STR
- b) Simultaneous analysis of STR, SNP, InDels and mitochondrial DNA
- c) Greater resolution in complex mixtures
- d) Capacity to work with highly degraded DNA

Emerging applications:

- a) Identification in mass disasters
- b) Analysis of ancient or degraded remains
- c) Differentiation between genetically close individuals

Challenges:

- a) Costs and accessibility
- b) Standardisation of protocols
- c) Validation for routine forensic use
- d) Bioinformatic complexity

Despite these limitations, NGS is emerging as the future standard in forensic genetics.

10.4 FORENSIC EPIGENETICS

Epigenetics introduces a new dimension into human identification by analysing chemical modifications of DNA that do not alter the sequence, such as methylation.

Potential applications:

- a) Differentiation between monozygotic twins
- b) Estimation of biological age
- c) Identification of tissue type
- d) Inference of environmental exposures

Unlike classic genetic markers, epigenetic patterns can vary between genetically identical individuals, which opens new possibilities in previously unsolvable cases.

Current limitations:

- a) Inter-individual variability
- b) Environmental influence
- c) Lack of standardisation
- d) Need for validation in forensic contexts

10.5 INTEGRATION OF BIG DATA AND BIOINFORMATICS

The exponential growth of genetic data has driven the development of advanced bioinformatic tools for their analysis.

Key components:

- a) Large-scale genetic databases
- b) Probabilistic analysis algorithms
- c) Simulation of kinship scenarios
- d) Automation of interpretation

The integration of big data will allow:

- a) Better estimation of allelic frequencies
- b) More precise population analysis
- c) Large-scale kinship evaluation

10.6 FUTURE PERSPECTIVES

The future of forensic genetics is oriented towards:

- a) Integrated multimodal approaches (STR + SNP + NGS + epigenetics)
- b) Automation through artificial intelligence
- c) Greater precision in complex scenarios
- d) Reduction of analysis times
- e) Expansion towards new applications (phenotyping, genetic genealogy)

Nevertheless, these advances must be accompanied by:

- a) Adequate ethical regulation
- b) Rigorous scientific validation
- c) Specialised training of professionals

Conclusion of the section

Emerging trends are transforming forensic genetics into a highly technological and interdisciplinary discipline. The integration of artificial intelligence, massively parallel sequencing, epigenetics and large-scale data analysis is significantly broadening the capacities of genetic identification. However, the main challenge lies in balancing technological innovation with scientific validation, methodological standardisation and respect for ethical and legal principles.

11 DETERMINATION OF PATERNITY AT THE PRENATAL LEVEL

11.1 INTRODUCTION

Prenatal paternity determination represents an advanced extension of forensic and clinical genetics, which allows biological filiation to be established before birth. This type of analysis has evolved from traditional invasive methods towards non-invasive approaches based on cell-free fetal DNA in maternal blood, significantly improving the safety and acceptability of the procedure.

11.2 BIOLOGICAL BASES OF FETAL DNA

During pregnancy, fragments of fetal DNA (mainly of placental origin) circulate freely in maternal plasma, known as cell-free fetal DNA (cffDNA).

Key characteristics:

- a) Detectable from week 5–7 of gestation
- b) Variable fetal fraction (generally 5–20%)
- c) Short half-life (rapid elimination postpartum)
- d) High fragmentation (~150–200 bp)

These properties allow its analysis by highly sensitive molecular techniques.

11.3 INVASIVE METHODS

Traditional methods involve the direct obtaining of fetal material:

a) Amniocentesis

- a) Performed between weeks 15–20
- b) Obtaining of amniotic fluid
- c) Risk of fetal loss: ~0.1–0.3%

b) Chorionic villus sampling (CVS)

- a) Performed between weeks 10–13
- b) Obtaining of placental tissue
- c) Slightly higher risk than amniocentesis

Application:

- a) They allow high-quality fetal DNA to be obtained
- b) Analysis by standard STR

Limitations:

- a) Clinical risk
- b) Ethical considerations
- c) Need for medical indication

11.4 NON-INVASIVE METHODS (NIPPT)

The most significant advance in prenatal paternity is the development of Non-Invasive Prenatal Paternity Testing (NIPPT).

Principle:

- a) Analysis of cell-free fetal DNA in maternal plasma
- b) Comparison with the DNA of the alleged father

Technologies used:

- a) Massively parallel sequencing (NGS)
- b) High-density SNP panels (thousands of markers)
- c) Advanced statistical models

Advantages:

- a) No risk for the fetus
- b) High sensitivity
- c) Applicable from early stages of pregnancy

Technical challenges:

- a) Low fetal fraction
- b) Mixture with maternal DNA
- c) Need for deconvolution algorithms
- d) High cost

11.5 ANALYTICAL AND STATISTICAL APPROACH

Prenatal analysis requires specific adaptations:

In STR:

- a) More complex interpretation due to maternal-fetal mixture
- b) Limited use in non-invasive methods

In SNP:

- a) Identification of paternal alleles not present in the mother
- b) Use of thousands of markers to increase statistical power

Probabilistic model:

Adapted Likelihood Ratios are used that consider:

- a) Fetal fraction
- b) Sequencing error
- c) Allelic distribution

11.6 LIMITATIONS AND SOURCES OF ERROR

Biological factors:

- a) Low fetal fraction (<4%)
- b) Placental mosaicism
- c) Multiple pregnancies

Technical factors:

- a) Sequencing errors
- b) Contamination
- c) Biases in amplification

Interpretative factors:

- a) Dependence on population databases
- b) Complexity of statistical models

11.7 SPECIFIC ETHICAL AND LEGAL CONSIDERATIONS

Prenatal paternity raises particular ethical challenges:

- a) Right of the fetus to protection
- b) Psychological impact on the mother
- c) Possible use in reproductive decisions
- d) Reinforced informed consent

The guidelines of the International Society for Forensic Genetics recommend:

- a) Prior ethical evaluation
- b) Careful communication of results
- c) Restriction of use to appropriate contexts

11.8 CLINICAL AND FORENSIC APPLICATIONS

- a) Determination of filiation in legal disputes
- b) Cases of sexual violence
- c) Complex family studies
- d) Early evaluation of kinship

11.9 FUTURE PERSPECTIVES

The field of prenatal paternity continues to evolve towards:

- a) Greater precision in NIPPT
- b) Integration with artificial intelligence
- c) Reduction of costs

d) Expansion of genetic panels

It is expected that these advances will consolidate non-invasive methods as the standard in the near future.

Conclusion of the section

Prenatal paternity determination represents a significant advance in applied genetics, allowing the evaluation of filiation with high levels of precision before birth. The transition towards non-invasive methods has improved safety and has broadened the clinical and forensic applications. However, its implementation requires a careful balance between technological innovation, scientific validation and ethical responsibility.

12 FINAL CONCLUSION

Paternity studies based on DNA analysis have evolved from methodologies of limited resolution towards highly sophisticated platforms that integrate multiplex STR systems, SNP markers and massively parallel sequencing technologies. This transition has consolidated forensic genetics as a tool of extraordinary precision and robustness for the determination of biological relationships, even in scenarios of high complexity.

In contemporary practice, paternity analysis transcends the simple comparison of genetic profiles and is based on a multidisciplinary approach that combines molecular biology, population genetics and Bayesian statistical models. This framework allows the strength of the evidence to be objectively quantified through likelihood ratios, guaranteeing reproducible and scientifically defensible results in the judicial sphere. The adoption of international standards promoted by bodies such as the Scientific Working Group on DNA Analysis Methods and the International Society for Forensic Genetics has been decisive in ensuring analytical quality and the correct interpretation of results.

The incorporation of emerging technologies, in particular next-generation sequencing, has substantially broadened the resolving capacity of genetic analysis, allowing intralocus variation to be characterised, multiple types of markers to be integrated and the interpretation in degraded samples or complex mixtures to be optimised. These advances have allowed classic limitations to be overcome, especially in contexts of collateral kinship, consanguinity or absence of one of the progenitors.

However, this technological progress also introduces relevant challenges, among them the need for global standardisation, the development of robust bioinformatic tools and the specialised training of professionals. Likewise, the adequate selection of population databases and the rigorous application of statistical models continue to be critical aspects to avoid biases in the probabilistic evaluation.

From an ethical and legal perspective, the application of these techniques requires responsible handling of genetic information, based on respect for confidentiality, informed consent and clear and precise communication of results. The correct interpretation of probabilistic language in the judicial sphere is essential to prevent errors and guarantee well-founded decisions.

Taken together, paternity studies through DNA constitute a paradigm of integration between science, technology and law. Their future development will be marked by the adoption of multimodal approaches, the incorporation of artificial intelligence and the analysis of large volumes of genetic data, which will allow even greater levels of precision, efficiency and reliability to be reached in the resolution of forensic cases.

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CONSENSUALISM IN PUBLIC ADMINISTRATION AS A TOOL FOR ACCESS TO JUSTICE

CONSENSUALISMO NA ADMINISTRAÇÃO PÚBLICA COMO FERRAMENTA DE ACESSO À JUSTIÇA

EL CONSENSUALISMO EN LA ADMINISTRACIÓN PÚBLICA COMO HERRAMIENTA DE ACCESO A LA JUSTICIA



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ABSTRACT

This paper investigates the role of consensualism in Public Administration as an instrument for broadening access to justice in its effective dimension. It starts from the premise that access to justice is not limited to formal access to courts, but encompasses the achievement of adequate, timely, proportional and materially fair solutions to conflicts. To this end, it examines the relativisation of the principles of supremacy and unavailability of the public interest, distinguishing the unavailability of public interest from its alleged non-transactionability. The research adopts a deductive method, based on bibliographical review, normative analysis and recent institutional data from the National Council of Justice and the Federal Court of Accounts. The analysis covers four axes: the relativisation of the classical dogmas of administrative law; the normative and institutional consolidation of consensual Public Administration; the relationship between consensuality and effective access to justice; and the limits, risks and controls applicable to administrative agreements. The paper concludes that consensualism, when subject to legality, reasoning, transparency, control and protection of the primary public interest, constitutes a relevant instrument for litigation prevention, rationalisation of state action and realisation of a fair legal order.

Keywords: Access to Justice. Consensuality. Public Administration. Public Interest. External Control.

RESUMO

O presente trabalho investiga a função do consensualismo na Administração Pública como instrumento de ampliação do acesso à justiça em sua dimensão efetiva. Parte-se da premissa de que o acesso à justiça não se limita ao ingresso formal no Poder Judiciário, mas compreende a obtenção de soluções adequadas, tempestivas, proporcionais e materialmente justas para os conflitos. Para tanto, examina-se a relativização dos princípios da supremacia e da indisponibilidade do interesse público, distinguindo-se a indisponibilidade do interesse público de sua suposta intransacionabilidade. A pesquisa adota método dedutivo, com base em revisão bibliográfica, análise normativa e utilização de

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dados institucionais recentes do Conselho Nacional de Justiça e do Tribunal de Contas da União. A análise percorre quatro eixos: a relativização dos dogmas clássicos do regime jurídico-administrativo; a consolidação normativa e institucional da Administração Pública consensual; a relação entre consensualidade e acesso efetivo à justiça; e os limites, riscos e controles aplicáveis aos acordos administrativos. Conclui-se que o consensualismo, quando submetido a critérios de juridicidade, motivação, transparência, controle e proteção do interesse público primário, constitui instrumento relevante de prevenção de litígios, racionalização da atuação estatal e concretização de uma ordem jurídica justa.

Palavras-chave: Acesso à Justiça. Consensualidade. Administração Pública. Interesse Público. Controle Externo.

RESUMEN

El presente trabajo investiga la función del consensualismo en la Administración Pública como instrumento de ampliación del acceso a la justicia en su dimensión efectiva. Se parte de la premisa de que el acceso a la justicia no se limita al ingreso formal en el Poder Judicial, sino que comprende la obtención de soluciones adecuadas, oportunas, proporcionales y materialmente justas para los conflictos. Para ello, se examina la relativización de los principios de la supremacía y de la indisponibilidad del interés público, distinguiéndose la indisponibilidad del interés público de su supuesta intransaccionabilidad. La investigación adopta el método deductivo, con base en revisión bibliográfica, análisis normativo y utilización de datos institucionales recientes del Consejo Nacional de Justicia y del Tribunal de Cuentas de la Unión. El análisis recorre cuatro ejes: la relativización de los dogmas clásicos del régimen jurídico-administrativo; la consolidación normativa e institucional de la Administración Pública consensual; la relación entre consensualidad y acceso efectivo a la justicia; y los límites, riesgos y controles aplicables a los acuerdos administrativos. Se concluye que el consensualismo, cuando se somete a criterios de juridicidad, motivación, transparencia, control y protección del interés público primario, constituye un instrumento relevante de prevención de litigios, racionalización de la actuación estatal y concreción de un orden jurídico justo.

Palabras clave: Acceso a la Justicia. Consensualidad. Administración Pública. Interés Público. Control Externo.

1 INTRODUCTION

Brazilian Public Administration has historically been structured under the strong influence of a verticalised logic, founded on the prevalence of state power over the individual and supported by the principles of supremacy and unavailability of the public interest. This model, although it has played a relevant role in affirming administrative authority and protecting public assets, proves insufficient to respond, on its own, to the contemporary demands of efficiency, participation, transparency and effectiveness of fundamental rights.

The consolidation of the Democratic Rule of Law imposed on Public Administration the need to abandon an exclusively unilateral, imposing and bureaucratic action, opening space for more dialogical, cooperative and responsive practices. Contemporary Administration cannot be understood merely as an authority that orders, oversees and sanctions, but also as an instance that prevents conflicts, negotiates legally adequate solutions and promotes the concrete realisation of the public interest. In this sense, consensual Administration appears as one of the most relevant facets of the transformation of Administrative Law in the twenty-first century, linked to public governance, the network State and the democratisation of administrative decision-making (Oliveira; Schwanka, 2009).

The relevance of the theme becomes even more evident in view of the structural framework of litigiousness in Brazil. The report *Justiça em Números 2025*, base year 2024, released by the Conselho Nacional de Justiça, recorded the existence of 80.6 million pending cases at the end of 2024. The same report indicated that the congestion rate fell to 64.3%, the lowest index in the last 16 years, and that the stock of tax foreclosures decreased by 5.5 million actions in 2024. These data demonstrate that, although there is progress in judicial productivity, the broadening of access to justice cannot be understood merely as an expansion of the jurisdictional channel, but should include adequate mechanisms for the prevention, management and consensual resolution of conflicts (Conselho Nacional de Justiça, 2025).

Litigiousness involving the Public Power also takes on special relevance. In a statement recorded in the minutes of the Conselho Nacional de Justiça, minister Luís Roberto Barroso reported that the Instituto Nacional do Seguro Social was the largest litigant in the Brazilian justice system, involved in 4.5% of pending cases, followed by the Caixa Econômica Federal, with 2.86%. The same statement highlighted the recurrent presence of public entities among the largest litigants in the country, which reinforces the need for policies for the prevention and administrative resolution of conflicts involving the State (Conselho Nacional de Justiça, 2024).

In view of this scenario, the following research question is formulated: to what extent can consensualism in Public Administration function as an instrument for broadening effective access to justice, without violating the unavailability of the public interest?

The hypothesis adopted is that administrative consensuality, when correctly delimited by criteria of legality, reasoning, transparency, control and protection of the primary public interest, contributes to the reduction of litigiousness and to the delivery of faster, more efficient and more democratic solutions to conflicts involving the Public Power.

The general objective consists in analysing to what extent administrative consensualism can broaden effective access to justice. As specific objectives, it seeks to examine the relativisation of the classical dogmas of administrative law; to identify the consensual instruments incorporated into Brazilian positive law; to analyse the relationship between consensuality and effective access to justice; and to delimit the limits and controls applicable to administrative agreements.

The work is organised into five sections. After this introduction, the theoretical background presents the conceptual foundations of the research, articulating the relativisation of the supremacy and unavailability of the public interest, the theory of consensual Administration and the contemporary conception of access to justice. The methodology describes the procedures adopted for the bibliographical and documentary research. The results and discussion examine the normative and institutional instruments in the light of the theoretical framework, organising the findings into thematic axes. The final considerations resume the objectives, synthesise the results and point out perspectives for future research and regulation.

2 THEORETICAL BACKGROUND

Understanding administrative consensuality as an instrument of access to justice presupposes the articulation of a theoretical framework that runs, from the general to the specific, through the foundations of administrative law, the theory of consensual Administration and the contemporary conception of access to justice. The necessary starting point is the critical analysis of the principles of supremacy and unavailability of the public interest, traditionally conceived as foundations of administrative law, justifying special prerogatives of the Administration and limits on the action of public agents.

Beyond the principles expressly provided for in article 37 of the Constituição Federal — legality, impersonality, morality, publicity and efficiency —, classical doctrine recognises the existence of implicit principles that structure administrative action, among them the supremacy and unavailability of the public interest. Supremacy would authorise the

prevalence of the collective interest over individual interests in certain situations; unavailability, in turn, would prevent the administrator from treating public assets, rights and interests as if they were of his free ownership.

For Bandeira de Mello (2004), such principles constitute pillars of administrative law, insofar as they translate, on the one hand, the prerogatives necessary for the realisation of the public interest and, on the other, the subjections imposed on the administrator, who does not act in his own name, but in the name of the community. This understanding, however, came to be the object of revision by an important portion of contemporary doctrine.

Authors such as Ávila (1998), Justen Filho (2005) and Binenbojm (2010) reject the idea of an automatic, abstract and absolute prevalence of the public interest over the private interest. Ávila (1998) problematises the very configuration of the supremacy of the public interest as a principle, sustaining that the statement would lack the normative structure proper to norm-principles. Binenbojm (2010), in turn, defends the replacement of abstract supremacy with a duty of proportionality, so that the relationship between collective and private interests is resolved through constitutionally oriented weighting. Justen Filho (2005) also rejects the existence of a previously defined privileged state position, since the State is subject to the Constitution and to fundamental rights.

In a convergent sense, and from a complementary angle, Marques Neto (2015, p. 386) sustains that supremacy, by combining absoluteness and abstraction, is proper to the bipolar paradigm and stands as the antipode of the ideas of weighting, modulation and balancing, revealing itself, by presupposing an absolute relational notion, incompatible with the legal order itself (Marques Neto, 2015, p. 387). The same critique reaches the idea of a unitary public interest: it is an indeterminate, open and ductile notion, so that there is not one, but several public interests entangled in each provision of the Administration (Marques Neto, 2015, p. 388).

This revision is fundamental for the development of a consensual Public Administration. If the public interest is not an abstract formula monopolised by the State, but a constitutionally oriented construction, its realisation may occur by different means, including the consensual route. From such a perspective, consensus does not represent abdication of the public interest, but a possible technique for its realisation.

The distinction between primary and secondary public interest also proves relevant. The primary public interest corresponds to the realisation of the needs, rights and purposes of the community; the secondary one concerns the instrumental interests of the State itself, such as the preservation of the public treasury or of the administrative structure. The generic invocation of the supremacy of the public interest, without concrete identification of the

protected collective interest, may produce imbalances in the relations between Administration and citizen, limiting social participation and obscuring the public purpose of administrative action (Lima, 2025).

The unavailability of the public interest, in turn, cannot be confused with its absolute non-transactionability. The Administration does not freely dispose of the public interest, but may transact regarding the means of its realisation when the consensual solution proves more adequate, efficient and proportional than the litigious or imposing route. As Talamini (2005) observes, the unavailability of the public interest does not lead, in itself, to the impossibility of the Public Power submitting to others' claims or abdicating certain positions, provided it does so in a legally justified manner.

In a formulation that precedes the current debate, Moreira Neto (2003, p. 142) already described the passage from a vicious relationship of supremacy to a virtuous relationship of weighting, preventing reasons of State from being invoked to place any interests above fundamental rights. Based on the theory of the double degree, the author distinguished primary state power — absolute and non-negotiable — from secondary power, relative and negotiable, located in the plane of discretionary decisions (Moreira Neto, 2003, p. 139). It is in this key that the distinction adopted here is understood: in consensual action, there is never any consideration of negotiating the public interest, but of negotiating the ways of achieving it with greater efficiency (Moreira Neto, 2003, p. 154).

This understanding is reinforced by Dantas (2020), in sustaining that transaction in the Public Power should not be understood as an arbitrary renunciation of the collective interest, but as a technique of administrative efficiency and rationality, provided it is directed at the realisation of the primary public interest. The core of the problem, therefore, does not lie in knowing whether or not the Administration can compromise in the abstract, but in identifying about what, under which conditions, with which controls and with what purpose the administrative transaction may occur.

On this basis, consensual Public Administration is inserted in a broader movement of transformation of the State. The passage from a monological, authoritarian action centred on imposition to a dialogical, participatory and result-oriented action relates to the ideas of public governance, network State and contractualisation of administrative action.

On the theoretical plane, this transition finds a framework in the thesis of Marques Neto (2015, p. 404-406) on the overcoming of the bipolar paradigm — founded on the opposition between State and individual, public and private — by a relational and multipolar paradigm, associated with the notion of Public Arena. For the author, administrative activity does not dispense with cooperation with private parties, engaging with them not only in

relations of subordination, on the vertical axis, but in countless relations of cooperation and composition, on the horizontal axis, marked by consensuality and by the obligational bond (Marques Neto, 2015, p. 389). In this reading, public and private, previously held as separate worlds, present themselves as interpenetrated entities, so that the administrative decision comes to admit weighting and composition of interests (Marques Neto, 2015, p. 405-406).

Oliveira and Schwanka (2009) argue that consensual Administration constitutes a new face of Public Administration in the twenty-first century. For the authors, the contemporary State ceased to act only as holder of the power of empire and came to exercise, in various situations, functions of mediation, guarantee and composition of interests, including citizens and social groups in the process of densification of the public interest, which ceases to be an exclusive monopoly of the state authorities.

In the same direction, Medauar (2003) observes that the activity of consensus-negotiation between Public Power and private parties comes to play a relevant role in the identification of the public and private interests protected by the Administration. For the author, the Public Power ceases to hold exclusivity in the definition of the public interest, attenuates the practice of unilateral imposition of decisions and comes to assume a function of mediation in the composition of conflicts. Castro and Figueroa (2013), in turn, associate the evolution of consensualism with the need to distinguish the traditional bureaucratic model from a responsible public management, concerned with results and with the realisation of the principle of efficiency.

The dogmatic systematisation of this transition, in Brazil, dates back to Moreira Neto (2003, p. 146), who coined the notion of concerted administration to designate the organisational and functional modules characterised by consensual and negotiated activity, classifying it into three genres according to the function and the result sought: the consensual decision, the consensual execution and the consensual resolution of conflicts (Moreira Neto, 2003, p. 147). It was already then recognised that consensus improves governability, multiplies the checks against abuses and makes state commands more acceptable (Moreira Neto, 2003, p. 145).

The third theoretical axis is the contemporary conception of access to justice. Access to justice constitutes a fundamental right expressly guaranteed by article 5, item XXXV, of the Constituição Federal of 1988, according to which "the law shall not exclude from the appreciation of the Judiciary any injury or threat to a right" (Brasil, 1988). Although this provision enshrines the inafastability of jurisdiction, the contemporary understanding of access to justice cannot be reduced to the mere formal possibility of bringing a case to court:

it is a matter of guaranteeing adequate, effective, timely and materially fair means of prevention and resolution of conflicts.

This understanding can be deepened from the contractualist tradition. According to Bonilla Maldonado (2022), the constitution of the modern State represents the replacement of private revenge with institutionalised justice, since individuals accept limiting part of their freedom in exchange for protection, stability and legitimate resolution of conflicts. If the modern State legitimates itself, among other factors, by this replacement of private violence with institutional forms of conflict resolution, the realisation of justice may also occur through legally structured consensual mechanisms, and not only through judicial judgment.

The theory of the renewing waves of Cappelletti and Garth (1988) provides the decisive reference for this broadened understanding. The first wave relates to legal assistance to the underprivileged; the second, to the protection of diffuse and collective interests; and the third, to the reform of procedures and the valuing of adequate means of conflict resolution. Administrative consensuality is situated in this third movement, since it shifts the resolution of certain controversies from the exclusively judicial logic to more flexible, dialogical and efficient mechanisms, without removing the necessary legal control.

Finally, Abramovich and Courtis (2004), in analysing the enforceability of social rights, demonstrate that the jurisdictional protection of benefit-related rights faces particular challenges, since the mere judicial recognition of state non-compliance is not always sufficient to ensure the material realisation of the right. The effectiveness of justice, in these cases, requires mechanisms capable of transforming legal recognition into concrete, coordinated and enforceable measures, which reinforces the importance of consensual instruments apt to construct viable, controllable solutions compatible with the rights involved.

3 METHODOLOGY

This research adopts a qualitative approach, of a basic nature and exploratory and descriptive objectives, developed through bibliographical and documentary research. The choice of the qualitative approach is justified by the need to examine, in depth, the meanings attributed to administrative consensuality and to access to justice in doctrine, legislation and the institutional action of oversight bodies, a field in which the understanding of the normative and dogmatic aspects involved requires interpretative instruments that are not reduced to quantitative measurement.

The method of approach is deductive: it starts from the general premises of administrative law and of the theory of access to justice to examine the specific hypothesis that consensuality, when legally conditioned, broadens effective access to justice. As

research techniques, the bibliographical survey of national and foreign doctrine of Administrative Law, Procedural Law and the theory of access to justice was employed, as well as the documentary survey of normative and institutional sources.

The normative corpus brought together the Constituição Federal of 1988 and Laws n. 7.347/1985, 9.307/1996, 13.129/2015, 13.140/2015, 13.655/2018 and 14.133/2021, in addition to Resolution n. 125/2010 of the Conselho Nacional de Justiça. The documentary and institutional corpus comprised the report Justiça em Números 2025 and the minutes of the 2nd Extraordinary Session of 2024 of the Conselho Nacional de Justiça, the Recommendatory Note n. 02/2022 of Atricon, and the acts and institutional communication of the Tribunal de Contas da União on the Secretariat of External Control of Consensual Resolution and Conflict Prevention, in particular Normative Instructions TCU n. 91/2022 and n. 101/2025.

The selected material was subjected to qualitative content analysis, with the identification of thematic categories related to the objectives of the research, namely: (a) the relativisation of the supremacy and unavailability of the public interest; (b) the normative instruments of consensual Administration; (c) the relationship between consensuality and effective access to justice; (d) the risks of asymmetry in administrative agreements; and (e) the limits and controls of consensuality. The ethical aspects of the research were observed: all the sources consulted are cited and referenced in accordance with the ABNT norms, without undue appropriation of ideas or data; due to its bibliographical and documentary nature, the study did not involve the participation of human subjects, dispensing with submission to a Research Ethics Committee.

The main methodological limitation lies in the bibliographical and documentary nature of the corpus, which does not contemplate the empirical analysis of concrete administrative agreements nor the perceptions of public managers and private parties involved in composition processes. This limitation guides the suggestions for future research with empirical and participatory designs. Table 1 synthesises the main references mobilised and their contributions to the theoretical and analytical construction of the study.

Table 1

References and their contributions to the research

Author	Title	Year	Contribution to the research
Abramovich, V.; Courtis, C.	Los derechos sociales como derechos exigibles	2004	Highlights the limits of jurisdictional protection for the material realisation of benefit-related rights.

Ávila, H. B.	Repensando o "princípio da supremacia do interesse público sobre o particular"	1998	Questions the configuration of supremacy as a principle endowed with abstract and automatic prevalence.
Bandeira de Mello, C. A.	Curso de direito administrativo	2004	Systematises the supremacy and unavailability of the public interest as pillars of administrative law.
Binenbojm, G.	Da supremacia do interesse público ao dever de proporcionalidade	2010	Proposes replacing abstract supremacy with a constitutionally oriented duty of proportionality.
Bonilla Maldonado, D.	Acceso a la justicia y Estado moderno	2022	Relates access to justice to the rationality of the modern State and to the replacement of self-protection by institutionalised justice.
Cappelletti, M.; Garth, B.	Acesso à justiça	1988	Provides the theory of renewing waves and the notion of effective access to justice.
Castro, R. P. A. de; Figueroa, R. O.	Breve ensaio sobre o consensualismo na Administração Pública	2013	Associates consensualism with the overcoming of the bureaucratic model and with result-oriented public management.
Dantas, B.	Consensualismo, eficiência e pluralismo administrativo: a mediação pelo TCU	2020	Defends transaction and mediation in external control as techniques of administrative efficiency.
Fiss, O.	As bases políticas e sociais da adjudicação	2004	Warns about the risks of agreement as an instrument that may conceal asymmetries of power between the parties.
Galanter, M.	Why the "Haves" Come Out Ahead	1974	Contributes the theory of repeat players and the structural asymmetry between recurrent and occasional litigants.
Justen Filho, M.	Curso de direito administrativo	2005	Refutes the previously defined privileged state position, subjecting the State to the Constitution.
Lima, C. V. N. de	Breves considerações sobre a utilização do consensualismo na Administração Pública	2025	Discusses the distinction between primary and secondary public interest and the risks of the generic invocation of supremacy.

Marques Neto, F. A.	A bipolaridade do direito administrativo e sua superação	2015	Demonstrates the incompatibility of supremacy with weighting and proposes the overcoming of the bipolar paradigm.
Medauar, O.	O direito administrativo em evolução	2003	Identifies the activity of consensus-negotiation as a function of mediation in the composition of interests.
Moreira Neto, D. de F.	Novos institutos consensuais da ação administrativa	2003	Formulates the notion of concerted administration and the distinction between negotiating the public interest and the ways of achieving it.
Oliveira, G. J. de; Schwanka, C.	A administração consensual como a nova face da Administração Pública no século XXI	2009	Characterises consensual and mediating Administration as a central feature of contemporary Administrative Law.
Pereira, C. A. <i>et al.</i>	O consensualismo nos Tribunais de Contas: a nova onda de acesso à justiça	2025	Examines the consensual instruments in external control as a broadening of access to justice.
Talamini, E.	A (in)disponibilidade do interesse público	2005	Distinguishes the unavailability of the public interest from its alleged non-transactionability.

Source: prepared by the authors (2026).

The organisation in alphabetical order facilitates the location of the sources and evidences the articulation between the dogmatic, normative and institutional dimensions that sustain the analysis developed in the following sections.

4 RESULTS AND DISCUSSION

The analysis of the bibliographical, normative and institutional material allowed the findings to be organised into five thematic axes, examined below in the light of the theoretical framework: the normative consolidation of consensual instruments; the relationship between consensuality and effective access to justice; the critique of agreements and the risk of asymmetry; the limits and controls of consensuality; and the institutional experience of the Courts of Accounts.

With regard to normative consolidation, it was found that the transformation described in the theoretical framework finds broad support in Brazilian positive law. Resolution n. 125/2010 of the Conselho Nacional de Justiça instituted the National Judiciary Policy for the adequate treatment of conflicts, strengthening the culture of conciliation and mediation. The

Code of Civil Procedure of 2015 enshrined self-composition as a guideline of the procedural system, by determining that conciliation, mediation and other methods of consensual resolution be stimulated by magistrates, lawyers, public defenders and members of the Public Prosecutor's Office.

In the specific field of Public Administration, Law n. 13.140/2015 provides for mediation and self-composition of conflicts within the scope of the Administration, foreseeing the creation of chambers for the prevention and administrative resolution of conflicts, competent to settle controversies between bodies and entities, evaluate requests for composition involving private parties and act in the prevention and resolution of conflicts relating to administrative contracts. Law n. 13.655/2018, in amending the Law of Introduction to the Norms of Brazilian Law, authorised, in article 26 of the LINDB, the conclusion of a commitment with interested parties to eliminate irregularity, legal uncertainty or contentious situation in the application of public law (Brasil, 2018).

Arbitration with Public Administration was expressly admitted by Law n. 13.129/2015, which amended Law n. 9.307/1996 to allow the direct and indirect Administration to use arbitration in conflicts relating to available patrimonial rights. Law n. 14.133/2021 consolidated this movement in the field of public procurement, authorising, in its articles 151 to 154, the use of conciliation, mediation, dispute resolution committee and arbitration in controversies over available patrimonial rights, such as economic-financial rebalancing, default of obligations and calculation of indemnities.

To these legislative instruments is added a set of already consolidated sectoral mechanisms, such as conduct adjustment terms, commitment terms in regulatory agencies, cessation commitments in the competition sphere, civil non-prosecution agreements, procedural legal transactions involving public entities and management adjustment terms before Courts of Accounts. The examination of this normative set evidences that consensual methods have ceased to occupy a peripheral or exceptional position, coming to integrate the ordinary institutional repertoire of Public Administration, especially in the areas in which unilateral imposition proves incapable of producing efficient, timely and sustainable solutions.

The second axis confirms the relationship between consensuality and effective access to justice. The figures of the report *Justiça em Números 2025*, already referred to in the introduction, evidence that access to justice cannot be thought of merely as a broadening of the Judiciary's entry door, but also as the creation of adequate doors for the prevention, management and resolution of conflicts (Conselho Nacional de Justiça, 2025). The litigiousness involving the Public Power aggravates this scenario, since public entities recurrently appear among the largest litigants in the country (Conselho Nacional de Justiça,

2024), which reveals that a significant part of the judicial overload stems from conflicts that could, in certain hypotheses, be prevented or resolved administratively.

From this perspective, consensual Public Administration can contribute to overcoming an adversarial culture marked by the automatic resistance of the State, by the standardised filing of appeals and by the delay in the administrative correction of illegal or inefficient conducts. Instead of litigating until the exhaustion of procedural channels, the Administration should evaluate, in a reasoned manner, when composition represents a more adequate solution to the primary public interest, to the rights of private parties and to administrative efficiency itself.

The third axis problematises the critique of agreements and the risk of asymmetry, avoiding an excessively optimistic understanding of consensuality. Fiss (2004) warns that judicial adjudication has a relevant public function, especially when it involves the affirmation of constitutional values, the correction of structural inequalities and the production of decisions with public impact. Although agreement is usually presented as a technique of pacification and efficiency, it may conceal material inequalities between the parties, especially when one of them has greater economic, institutional or informational power, a hypothesis in which the consensual solution does not express true autonomy, but constrained acceptance of conditions imposed by the stronger party (Fiss, 2004).

Within the scope of Public Administration, this warning is especially important. The State has a technical structure, a specialised legal body, accumulated information and institutional capacity to prolong litigation, which may place it in a position of advantage in relation to the private party, possibly in a situation of economic, technical or informational vulnerability. The theory of repeat players, associated with Galanter (1974), reinforces this diagnosis: public entities and large organisations tend to act repeatedly in conflicts, accumulating strategic experience, data and technical resources, which may produce institutional advantages in relation to occasional litigants. Thus, in concluding agreements with private parties, the Administration must ensure that the consensus does not reproduce, in an apparently cooperative form, the same verticality that is intended to be overcome.

Even so, when correctly structured, administrative consensus reinforces the democratic dimension of access to justice, since it allows the solution to be constructed with the participation of the interested parties, reduces costs, decreases response time, preserves continued relationships and favours the concrete implementation of public policies. Consensuality then ceases to be merely a technique of procedural management and comes to integrate a substantial conception of administrative justice.

The fourth axis delimits the limits and controls of consensuality, understood as a legally conditioned technique. The first limit is the transactionability of the object: the Administration cannot dispose of the essence of the primary public interest nor compromise on absolutely unavailable rights, while negotiation on the means of fulfilling obligations, deadlines, forms of execution, technical criteria, restoration of economic-financial balance, indemnities and other available patrimonial or instrumental aspects is admitted.

The second limit is reasoning: every administrative agreement must demonstrate, clearly, why the consensual solution is more adequate than the continuation of litigation or unilateral imposition, making explicit the public advantage, the risks avoided, the comparative costs and the compatibility with the applicable legislation. The third limit is transparency: as a rule, agreements must be public, except for the legal hypotheses of secrecy, since publicity allows social control, reduces risks of capture and strengthens the democratic legitimacy of the decision. The fourth limit is internal and external control, which is not removed by consensuality; on the contrary, the greater the complexity and repercussion of the agreement, the greater the degree of control over its legality, advantageousness and adherence to the public interest must be.

The fifth axis examines the institutional experience of the Courts of Accounts, which illustrates the viability of the proposed controls. Pereira *et al.* (2025) argue that instruments such as Management Adjustment Terms and Technical Tables express a paradigm shift in external control, which ceases to act only in a subsequent, repressive and sanctioning manner, coming to exercise a preventive, guiding and collaborative function, and contributing to broaden access to justice beyond the Judiciary. In the same sense, Atricon recommended that the Courts of Accounts adopt instruments of consensual conflict resolution in external control processes, observing administrative law (Atricon, 2022).

At the federal level, the experience of the Tribunal de Contas da União stands out. Since the beginning of 2023, the TCU has come to dedicate itself institutionally to the promotion of consensual solutions and the prevention of conflicts, through the Secretariat of External Control of Consensual Resolution and Conflict Prevention, based on Normative Instruction TCU n. 91/2022, subsequently amended by Normative Instruction TCU n. 101/2025. According to the Court itself, the normative update of 2025 broadened transparency, social participation, the criteria of admissibility and the flow of the processes, reflecting the experience accumulated in the treatment of controversies, with more than fifty cases in the unit, of which more than half had already been resolved (Tribunal de Contas da União, 2025).

This action dialogues with the proposal of Dantas (2020), who defends the adoption of mediation in the Tribunal de Contas da União as a mechanism apt to reduce the distance between manager and controller, especially in controversies relating to infrastructure contracts and economic-financial rebalancing. The set of these findings allows us to affirm that administrative consensuality must operate under a double key: openness to dialogue and submission to robust controls. Without dialogue, the Administration remains trapped in authoritarian rigidity and in litigiousness; without control, consensus may degenerate into favouritism, opacity or undue renunciation of the collective interest. The valid administrative agreement is, therefore, that which demonstrates, in a verifiable manner, its legality, its public advantage, its proportionality, its transparency and its compatibility with the fundamental rights involved.

5 FINAL CONSIDERATIONS

This article analysed consensualism in Public Administration as a tool for broadening access to justice in its effective dimension. The investigation started from the finding that the Brazilian Administration, historically founded on verticalised relations and unilateral prerogatives, has been progressively challenged by demands for efficiency, participation, governance, transparency and adequate resolution of conflicts.

The first conclusion is that the principles of supremacy and unavailability of the public interest can no longer be understood as absolute dogmas. Supremacy does not authorise the automatic prevalence of the State over the private party; unavailability does not amount to a prohibition of any transaction. What is forbidden is the undue renunciation of the primary public interest, not the legitimate negotiation of the most adequate means to realise it.

The second conclusion is that administrative consensuality is already incorporated into Brazilian positive law. The Mediation Law, the Code of Civil Procedure of 2015, the Arbitration Law, article 26 of the LINDB and Law n. 14.133/2021 demonstrate that self-composition has ceased to be an exceptional mechanism and has come to integrate the ordinary structure of prevention and resolution of conflicts involving Public Administration.

The third conclusion is that consensualism can broaden access to justice because it shifts attention from the mere entry into the Judiciary to the obtaining of effective, timely and adequate solutions. The data of the Conselho Nacional de Justiça demonstrate that the Brazilian judicial overload remains significant, despite the recent advances in productivity, and the repeated presence of public entities among the large litigants reinforces the need for a less adversarial Administration more committed to the prevention of conflicts.

The fourth conclusion is that the experience of the Courts of Accounts, especially of the TCU, reveals a promising institutional dimension of administrative consensuality. The creation of a unit dedicated to consensual resolution, the issuance of Normative Instruction TCU n. 91/2022 and its amendment by Normative Instruction TCU n. 101/2025 demonstrate that external control can act not only in a repressive manner, but also in a preventive, dialogical manner oriented towards the construction of legally secure solutions.

The fifth conclusion is that consensualism should not be treated as a panacea, since it presents risks, especially in contexts of informational asymmetry, vulnerability of the private party, administrative capture or decisional opacity. Fiss's critique of agreements and Galanter's theory of repeat players demonstrate that consensuality will only be legitimate when accompanied by procedural guarantees, reasoning, publicity and control.

The limitations of the study, of a bibliographical and documentary nature, are recognised, as it does not contemplate the empirical analysis of concrete agreements nor the perceptions of managers and private parties; for future research, empirical designs and comparative studies of regulatory models are suggested. In this way, administrative consensus, when correctly structured, does not represent a flight from Public Law, but a democratic updating of Administrative Law, allowing Public Administration to cease being merely a recurrent party in litigation and to act as an agent of prevention, composition and effective realisation of justice.

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CROSS-CULTURAL ADAPTATION AND VALIDATION OF THE NHS ENGLAND CLASSIFICATION OF LEVELS OF HARM ASSOCIATED WITH PATIENT SAFETY EVENTS FOR THE BRAZILIAN UNIFIED HEALTH SYSTEM (SUS): A STUDY PROTOCOL

ADAPTAÇÃO TRANSCULTURAL E VALIDAÇÃO DA CLASSIFICAÇÃO DOS NÍVEIS DE DANO ASSOCIADOS A EVENTOS DE SEGURANÇA DO PACIENTE DO NHS ENGLAND PARA O SISTEMA ÚNICO DE SAÚDE (SUS): UM PROTOCOLO DE ESTUDO

ADAPTACIÓN TRANSCULTURAL Y VALIDACIÓN DE LA CLASIFICACIÓN DE LOS NIVELES DE DAÑO ASOCIADOS A EVENTOS DE SEGURIDAD DEL PACIENTE DEL NHS ENGLAND PARA EL SISTEMA ÚNICO DE SALUD BRASILEÑO (SUS): UN PROTOCOLO DE ESTUDIO



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ABSTRACT

Patient safety is a strategic priority for health systems, and the classification of the level of harm is essential information for gauging the consequences of incidents, guiding institutional prioritisation, and supporting data comparability. In Brazil, the "degree of harm" field of the Health Surveillance Notification System (Notivisa), aligned with the International Classification for Patient Safety (ICPS), uses broad descriptors and does not structurally differentiate physical from psychological harm, which may increase interpretive variability among professionals and limit the comparability of the information. The levels-of-harm classification of NHS England, the body responsible for coordinating the National Health Service (NHS) in England, is part of the Learn from Patient Safety Events Service (LFPSE), distinguishes the categories of physical and psychological harm, and adopts descriptors and decision criteria potentially useful for the Brazilian context. This manuscript presents the protocol of a prospective methodological study aimed at developing, in Brazilian Portuguese and within the Brazilian Unified Health System (SUS), an adapted and validated version of the classification of levels of harm associated with patient safety events published by NHS England. The study will be conducted in sequential stages: initial translations, synthesis of the translations, back-translations, committee review of the translated document, normative and organisational contextualisation to the SUS, content validation using the Delphi method, and face validation with professionals who may use the classification in their institutional practice. There will be no direct patient involvement. The study is expected to produce a version conceptually equivalent to the source material and compatible with the normative and organisational context of the SUS, preserving the structure of harm categories, levels of harm, level descriptors, and decision criteria, and contributing to greater precision, standardisation,

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and comparability of harm-related information and to more proportionate, transparent, and learning-oriented institutional responses to patient safety events.

Keywords: Patient Safety. Patient Harm. Risk Management. Unified Health System. Cross-Cultural Comparison.

RESUMO

A segurança do paciente constitui prioridade estratégica dos sistemas de saúde, e a classificação do nível de dano é informação essencial para dimensionar as consequências dos incidentes, orientar a priorização institucional e favorecer a comparabilidade dos dados. No Brasil, o campo “grau do dano” do Sistema de Notificações para a Vigilância Sanitária (Notivisa), alinhado à Classificação Internacional para a Segurança do Paciente (CISP), utiliza descritores amplos e não diferencia, de forma estruturada, dano físico e dano psicológico, o que pode ampliar a variabilidade interpretativa entre profissionais e limitar a comparabilidade das informações. A classificação dos níveis de dano do NHS England, órgão responsável pela coordenação do Serviço Nacional de Saúde (National Health Service, NHS) na Inglaterra, integra o Learn from Patient Safety Events Service (LFPSE), distingue as categorias de dano físico e psicológico e adota descritores e critérios de decisão potencialmente úteis ao contexto brasileiro. Este manuscrito apresenta o protocolo de um estudo metodológico prospectivo para o desenvolvimento, em português brasileiro e no contexto do Sistema Único de Saúde (SUS), de uma versão adaptada e validada da classificação dos níveis de dano associados a eventos de segurança do paciente publicada pelo NHS England. O estudo será conduzido em etapas sequenciais: traduções iniciais, síntese das traduções, retrotraduções, revisão, por comitê, do documento traduzido, contextualização normativa e organizacional ao SUS, validação de conteúdo por método Delphi e validação de face com profissionais que poderão utilizar a classificação em sua prática institucional. Não haverá participação direta de pacientes. Espera-se produzir uma versão conceitualmente equivalente ao material de origem e compatível com o contexto normativo e organizacional do SUS, preservando a estrutura de categorias de dano, níveis de dano, descritores dos níveis e critérios de decisão, e contribuindo para maior precisão, padronização e comparabilidade das informações sobre dano e para respostas institucionais a incidentes de segurança do paciente mais proporcionais, transparentes e orientadas à aprendizagem.

Palavras-chave: Segurança do Paciente. Dano ao Paciente. Gestão de Riscos. Sistema Único de Saúde. Comparação Transcultural.

RESUMEN

La seguridad del paciente constituye una prioridad estratégica de los sistemas de salud, y la clasificación del nivel de daño es información esencial para dimensionar las consecuencias de los incidentes, orientar la priorización institucional y favorecer la comparabilidad de los datos. En Brasil, el campo “grado del daño” del Sistema de Notificaciones para la Vigilancia Sanitaria (Notivisa), alineado con la Clasificación Internacional para la Seguridad del Paciente (CISP), utiliza descriptores amplios y no diferencia, de forma estructurada, el daño físico del psicológico, lo que puede ampliar la variabilidad interpretativa entre profesionales y limitar la comparabilidad de la información. La clasificación de los niveles de daño del NHS England, organismo responsable de la coordinación del Servicio Nacional de Salud (National Health Service, NHS) en Inglaterra, integra el Learn from Patient Safety Events Service (LFPSE), distingue las categorías de daño físico y psicológico y adopta descriptores y criterios de decisión potencialmente útiles para el contexto brasileño. Este manuscrito presenta el protocolo de un estudio metodológico prospectivo dirigido a desarrollar, en portugués brasileño y en el contexto del Sistema Único de Salud brasileño (SUS), una versión adaptada y validada de la clasificación de los niveles de daño asociados a eventos

de seguridad del paciente publicada por el NHS England. El estudio se llevará a cabo en etapas secuenciales: traducciones iniciales, síntesis de las traducciones, retrotraducciones, revisión por comité del documento traducido, contextualización normativa y organizacional al SUS, validación de contenido mediante el método Delphi y validación de apariencia con profesionales que podrán utilizar la clasificación en su práctica institucional. No habrá participación directa de pacientes. Se espera producir una versión conceptualmente equivalente al material de origen y compatible con el contexto normativo y organizacional del SUS, preservando la estructura de categorías de daño, niveles de daño, descriptores de los niveles y criterios de decisión, y contribuyendo a una mayor precisión, estandarización y comparabilidad de la información sobre el daño y a respuestas institucionales a incidentes de seguridad del paciente más proporcionadas, transparentes y orientadas al aprendizaje.

Palabras clave: Seguridad del Paciente. Daño del Paciente. Gestión de Riesgos. Sistema Único de Salud. Comparación Transcultural.

1 INTRODUCTION

Patient safety constitutes a strategic priority for health systems, given the magnitude of preventable harm associated with care and its impact on the population's trust in health institutions (Panagioti *et al.*, 2019). This agenda was reinforced by the Global Action Plan for Patient Safety 2021-2030 of the World Health Organization (WHO), which directs governments and health organisations towards the elimination of preventable harm and the incorporation of safety as a dimension inseparable from the quality of care (World Health Organization, 2021).

The recording of the incident, however, is only the first step of the institutional response. Notification systems for learning depend on structured information, on the identification of patterns, and on the analysis of the elements that make up work processes and of the people who operate within them, so as to sustain improvement actions proportionate to the risk and impact of the incidents (Goekcimen *et al.*, 2022; McDonald *et al.*, 2010). Within this process, the classification of the level of harm to the patient is critical information: it gauges the effect of the incident, supports institutional prioritisation, guides communication, and sustains the comparability of data over time (Cooper *et al.*, 2018).

This function is inscribed within the classical logic of risk management. The international standard ISO 31000:2018 structures this process into stages of identification, analysis, evaluation, treatment, monitoring, and communication, an approach equally applicable to health organisations to ground decisions guided by consequences, priorities, and control measures (International Organization for Standardization, 2018).

In Brazil, the "degree of harm" field of the Health Surveillance Notification System (Notivisa), the national base for recording adverse events of the Brazilian Health Regulatory Agency (Anvisa), classifies the harm resulting from the patient safety incident into five levels (none, mild, moderate, severe, and death), in accordance with the International Classification for Patient Safety (ICPS) (Agência Nacional de Vigilância Sanitária, 2025). Developed by the WHO, the ICPS sought to address the absence of a common language in the field, harmonising concepts, terms, and definitions that favour the description, measurement, monitoring, and comparison of information on incidents between different services and health systems (World Health Organization, 2010).

Despite its relevance as a national reference, this field presents broad and succinct descriptors for the levels of harm, without making explicit decision criteria that are sufficiently operational to guide classification in the routine of services. Some descriptors resort to semantically broad expressions that are difficult to delimit, such as "short duration" and "long term", which may favour variable interpretations among professionals and compromise the

standardisation of the record. Added to this is the absence of structured differentiation between the categories of physical and psychological harm, which reduces analytical precision, increases interpretive variability, and compromises the comparability of data (Goekcimen *et al.*, 2022; Cooper *et al.*, 2018; Agência Nacional de Vigilância Sanitária, 2025).

The Global Patient Safety Report 2024, the first WHO report to present a comprehensive overview of the implementation of patient safety worldwide, aligned with the Global Action Plan for Patient Safety 2021-2030, adopts a multidimensional understanding of harm: in addition to physical harm, which may reach death or permanent disability, it considers the population scale of the problem and its economic, social, and psychological effects, and argues that policies, measurement, and institutional responses should contemplate this entire spectrum, and not only the immediate physical injury (World Health Organization, 2024).

The literature on the repercussions of adverse events on patients and family members confirms the understanding of harm proposed by the WHO, which contemplates different dimensions, by identifying physical, psychological, social, and financial impacts. Psychological harm is one of the most frequent and persistent dimensions, although it is still poorly recognised in institutional responses. It may manifest as anger, fear, guilt, grief, post-traumatic stress disorder (PTSD), and, in extreme cases, suicidal ideation, with effects that may last a decade or more. The way the institution responds to the event directly influences the intensity of this suffering, reinforcing the importance of empathetic communication, transparency, and continued psychological support following patient safety incidents (Ottosen *et al.*, 2021). In Brazil, the notification and classification instruments still concentrate predominantly on physical harm, which reinforces the need for a classification capable of recognising and measuring psychological harm as well.

In NHS England, the body responsible for coordinating the National Health Service (NHS) in England, a public service with universal coverage—a characteristic that converges with the structuring principles of the Brazilian Unified Health System (SUS)—the classification of levels of harm is part of the Learn from Patient Safety Events Service (LFPSE), a national platform for recording and learning from patient safety events (Weaver; Stewart; Kay, 2021; NHS England, 2023). The LFPSE replaced the National Reporting and Learning System (NRLS), the national repository of incident notifications in force since 2003, in the context of a broader reorganisation of patient safety in the country, driven by criticisms of the quality of investigations, the limited capacity to promote organisational learning, and the fragmentation of institutional responses within the NHS (Weaver; Stewart; Kay, 2021; Oikonomou *et al.*, 2019; Mesinioti *et al.*, 2025).

In comparison with the NRLS, the LFPSE strengthens an approach oriented towards learning and continuous improvement by incorporating more objective descriptors and decision criteria for the classification of levels of harm and by encouraging not only the recording of patient safety events but also of successful responses and improvements implemented from these events. Among its advances, the distinction between the categories of physical harm and psychological harm stands out, which confers greater precision to the characterisation of the consequences of patient safety incidents (NHS England, 2023).

This reorganisation of the NHS had as a structuring change the implementation of the Patient Safety Incident Response Framework (PSIRF), a national framework for responding to patient safety incidents that replaced the Serious Incident Framework (SIF), the previous model centred on the mandatory investigation of serious incidents. The PSIRF redefined the way the NHS guides the institutional response to incidents, coming to favour responses proportionate to the impact of the incident, the potential for learning, and the possibility of reducing future risks, rather than taking the severity of harm as the sole criterion for defining the conduct of the response. In this new arrangement, responses to incidents should involve the people affected, adopt a socio-technical analysis of the work system and the interactions between its components, promote qualified oversight of improvement actions, and translate the findings into timely redesign of processes (NHS England, 2022; Louch *et al.*, 2025; Iacobucci, 2019; Hallam, 2023).

The change was also accompanied by legislative and institutional initiatives. The Healthcare Safety Investigation Branch (HSIB), created in 2017 for the independent and systemic investigation of patient safety incidents (Dyer, 2017; Macrae, 2019; Crompton *et al.*, 2025), was subsequently converted into the Health Services Safety Investigations Body (HSSIB), a statutory body established by the Health and Care Act 2022 (Mayberry; Farrukh, 2026).

In Brazil, this debate gains momentum in light of recent milestones that reposition the patient and their safety at the centre of SUS decisions. Lei nº 15.378, de 6 de abril de 2026, which established the Estatuto dos Direitos do Paciente, recognises safety as a right and strengthens the participation of the patient in decisions and practices related to safe care (Brasil, 2026a). In a convergent manner, Portaria GM/MS nº 11.527, de 9 de junho de 2026, established the National Policy for Quality and Patient Safety (PNQSP) within the scope of the SUS, with the purpose of promoting safe, equitable, and person-centred care, as dimensions of the quality of health care, organised in an integral and territorialised manner and oriented towards the Health Care Networks (RAS) (Brasil, 2026b). In continuity with the National Patient Safety Programme (PNSP), established in 2013 (Brasil, 2013), these

milestones reinforce the need to qualify the information produced in notification, monitoring, and learning systems, including clearer and more consistent instruments to define the harm resulting from patient safety incidents.

The SUS is used directly by approximately 76% of the Brazilian population, accounts for around 2.8 billion appointments annually, and mobilises approximately 3.5 million professionals across multiple levels of care and care contexts (Castro *et al.*, 2019). On this scale, patient safety assumes a strategic character, and preventable harm acquires an expressive collective dimension, both due to the volume of people served and the role of the SUS as the only means of access to health for a significant portion of the population. Its repercussions fall on the continuity of care, operational efficiency, sustainability in the use of public resources, and social trust in the system (Kumah, 2025). National evidence gauges this effect: in a retrospective study conducted in Brazilian public hospitals, 65.7% of adverse events resulted in prolonged hospitalisation, a situation that exposes patients to additional risks, restricts the availability of beds, and compromises the access of other RAS users (Mendes *et al.*, 2018; Lima Júnior *et al.*, 2023).

It is in this scenario that the qualification of the classification of levels of harm assumes strategic value. The adoption of well-delimited harm categories, consistent levels of harm, clearer descriptors, and more objective decision criteria may standardise the information produced, support the identification of priorities and the definition of proportionate responses, in addition to promoting a more homogeneous understanding of the consequences of incidents among professionals from different services and regions. In a system of such breadth and care diversity, as is the SUS, the quality of these data sustains more equitable and transparent decisions and strengthens health management and surveillance (Goldman *et al.*, 2026).

Adopting a classification already consolidated in another system is a frequent strategy for this improvement; its transposition, however, cannot dispense with methodological rigour. Mere translation, even if reviewed by specialists, does not replace a formal process of cross-cultural adaptation and validation, which seeks to preserve the equivalence between the original and adapted versions in their semantic, idiomatic, experiential, and conceptual dimensions, in addition to contributing to content and face validity in the new context of application (Guillemin; Bombardier; Beaton, 1993; Beaton *et al.*, 2000; Alavi; Le Lagadec; Cleary, 2026).

In view of this scenario, this manuscript presents the protocol of a methodological study, of a prospective nature, aimed at conducting the translation, cross-cultural adaptation, and validation, into Brazilian Portuguese, of the classification of levels of harm associated

with patient safety events published by NHS England, with the objective of making available a version conceptually equivalent to the original and compatible with the normative and organisational context of the SUS. By structurally stratifying both physical and psychological harm, it is expected that this version will qualify the information produced in notification systems, favouring monitoring and learning and sustaining more proportionate and transparent responses to patient safety incidents in the SUS.

2 METHOD

2.1 STUDY DESIGN AND REPORTING REFERENCES

This is a protocol of a methodological study of a prospective nature, intended for the translation, cross-cultural adaptation, and validation, into Brazilian Portuguese, of the classification of levels of harm associated with patient safety events published by NHS England. The objective is to produce a version conceptually equivalent to the source material (Herdman; Fox-Rushby; Badia, 1998) and, simultaneously, compatible with the normative, organisational, and operational context of the SUS, so as to support institutional processes of notification, analysis, and monitoring of the response to patient safety incidents. The development will follow sequential and interdependent stages: initial translations, synthesis of the translations, back-translations, committee review of the translated document, normative and organisational contextualisation to the SUS, content validation using the Delphi method, and face validation with professionals who may use the classification in their institutional practice. There will be no inclusion of patients, collection of individualised clinical data, or implementation of care interventions.

The translation and adaptation process will adopt as a central reference the stages proposed by Beaton *et al.* (2000), complemented by the good practice principles of the International Society for Pharmacoeconomics and Outcomes Research (ISPOR) for translation and cross-cultural adaptation (Wild *et al.*, 2005) and by the guidelines of Sousa and Rojjanasrirat (2011). The generation and interpretation of validity evidence are guided by the framework of sources of validity evidence of the Standards for Educational and Psychological Testing (American Educational Research Association; American Psychological Association; National Council on Measurement in Education, 2014) and by the recommendations of the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) initiative, used in the pertinent aspects as support for the organisation of content validity evidence, considering that the object does not constitute a psychometric instrument nor produces a score (Terwee *et al.*, 2018). The reporting of the Delphi rounds will follow the Guidance on Conducting and Reporting Delphi Studies

(CREDES) (Jünger *et al.*, 2017). The protocol will be registered on the Open Science Framework (OSF), a platform maintained by the Center for Open Science (Center for Open Science, [s.d.]), prior to the start of data collection, providing transparency, dating, and reproducibility.

2.2 METHODOLOGICAL FOUNDATION

The translation and cross-cultural adaptation will seek to preserve the semantic, idiomatic, experiential, and conceptual equivalences between the source classification and the adapted version (Herdman; Fox-Rushby; Badia, 1998; Beaton *et al.*, 2000). Semantic equivalence will assess whether terms and statements preserve the meaning attributed in the source material; idiomatic equivalence will examine whether expressions characteristic of the English language have been rendered in a natural and comprehensible manner in Brazilian Portuguese; experiential equivalence will analyse whether the situations, practices, and criteria described are recognisable and applicable to Brazilian health services; and conceptual equivalence will verify whether the central concepts of the classification, especially those related to the categories of physical and psychological harm and the respective levels of harm, maintain their meaning in the normative, organisational, and care context of the SUS.

Considering that the object does not consist of a psychometric scale or self-report instrument, but rather an operational classification composed of harm categories, levels of harm, level descriptors, and decision criteria that do not produce numerical scores, the adaptation reference will be applied with adjustments to the nature of the object (Ye *et al.*, 2026; NHS England, 2023). The emphasis will fall on validity evidence based on content and on response processes, as well as on conceptual and normative consistency, with no analyses being carried out based on internal structure or relations with other variables, nor estimates of reliability through internal consistency, characteristic of psychometric instruments with a score. As a result of this nature, two stages of the reference of Beaton *et al.* (2000) will be adapted. The pre-test stage, originally conducted with patients, will be operationalised as face validation with professionals who may use the classification in their institutional practice, producing evidence related to comprehension, interpretability, and applicability of the criteria. The expert committee review stage provided for by Beaton *et al.* (2000) will be maintained according to the methodological reference, with the purpose of consolidating the translated material into a consensus version (section 2.7.4). Subsequently, the normative and organisational contextualisation to the SUS will be carried out, from which the pre-final version to be submitted for validation will result (section 2.7.5). In the absence

of a developer of the original instrument to whom to submit the final reports, the auditability of the process will be ensured by the systematic recording of decisions at all stages (Beaton *et al.*, 2000; Polit; Beck, 2006; Polit; Beck; Owen, 2007).

The conceptual and experiential equivalences, in this object, have a nature distinct from that observed in instruments whose items describe individual experiences. As the decision criteria refer to types of care, temporal parameters, levels of care intervention, and recording conditions regulated in a specific manner in each country, verifying whether these concepts maintain meaning and applicability in the SUS requires examining, in a systematic manner, the correspondence between the criteria of the source classification and the Brazilian normative, sanitary, and organisational framework, including the terminology adopted within the scope of the PNSP and the organisation of the incident response processes recommended by Anvisa. This examination constitutes the stage of normative and organisational contextualisation to the SUS and is, therefore, the procedure by which the conceptual and experiential equivalences are established in this study, and not an additional stage to the cross-cultural adaptation. By making explicit, systematic, and auditable a verification that, in strictly linguistic adaptations, would remain implicit, the contextualisation also constitutes the main methodological differential of this protocol. Its operationalisation, by means of a matrix of normative and conceptual correspondence, is detailed in section 2.7.5.

Content validation will be conducted using the Delphi method, with structured, anonymised, and iterative judgement by specialists, in accordance with Hasson, Keeney, and McKenna (2000), and estimated by the Item-level Content Validity Index (I-CVI), by the Scale-level Content Validity Index based on the average of the items (S-CVI/Ave), and by the modified kappa, according to Polit, Beck, and Owen (2007). Face validity will be examined based on evidence related to the response process of the professionals who may use the classification in their institutional practice: clarity, comprehensibility, organisation, interpretability, and usability, with calculation of the Item-level Face Validity Index (I-FVI) and the Scale-level Face Validity Index based on the average of the items (S-FVI/Ave), according to Yusoff (2019). Content and face validity will be interpreted in an integrated manner, articulating quantitative results, qualitative justifications, and evidence of normative and conceptual coherence, so as to maximise the robustness of the evidence and the reproducibility of the process (Sousa; Rojjanasrirat, 2011; Terwee *et al.*, 2018).

2.3 ORIGINAL DOCUMENT AND MATERIAL TO BE ADAPTED

The original material will be extracted from the section Definitions: harm grading of the electronic document Policy guidance on recording patient safety events and levels of harm,

published by NHS England under the reference PRN00444, on 15 August 2023, in the version updated on 16 March 2026, adopted as a reference in this study, with recording of the date of access and the electronic address for traceability purposes. The document constitutes technical-institutional guidance for the recording of patient safety events in the LFPSE and is made available under the Open Government Licence v3.0, which permits reuse, translation, and adaptation upon attribution of the original source (NHS England, 2023). In this study, the object of the adaptation is restricted to the classification of levels of physical and psychological harm presented in this section. Subsequent updates will only be incorporated upon specific and documented methodological deliberation.

For the purposes of this study, the classification will be understood from four structural components present in the source document. The first is the harm category, which indicates the type of harm to be recorded, physical or psychological. The second is the level of harm, which expresses the gradation of severity within each category. The third is the level descriptor, corresponding to the statement that characterises the general meaning of that level. The fourth is the decision criterion, understood as the operational condition that guides the framing of the harm at a given level.

The LFPSE replaces the single gradation previously used in the NRLS with a classification organised into two categories, physical and psychological, as synthesised in Table 1. The psychological harm category does not contemplate a level corresponding to the fatal outcome. The terms in Portuguese presented in this section and in Table 1 derive from one of the initial translations of the source document and are of a provisional nature, and may be modified in subsequent stages (Guillemin; Bombardier; Beaton, 1993; Beaton *et al.*, 2000; Alavi; Le Lagadec; Cleary, 2026).

Table 1

Comparison between the previous NRLS gradation and the levels of physical and psychological harm of the LFPSE

PREVIOUS GRADATION (NRLS / SINGLE MEASURE)	LEVELS OF PHYSICAL HARM (LFPSE)	LEVELS OF PSYCHOLOGICAL HARM (LFPSE)
No harm	No physical harm	No psychological harm
Low harm	Low physical harm	Low psychological harm
Moderate harm	Moderate physical harm	Moderate psychological harm
Severe harm	Severe physical harm	Severe psychological harm
Death	Fatal	Not applicable

Source: adapted from the section Definitions: harm grading of the electronic document Policy guidance on recording patient safety events and levels of harm, NHS England, published in 2023 and updated in March 2026.

The source document directs that the classification of the level of harm represent the effectively observed impact of the incident on the patient, based on the best information available at the time of recording. Thus, the classification should not be based on speculation about more serious potential harm, although it may be revised when new information becomes available. The attribution of the level of harm involves professional judgement and, whenever possible, should consider the perspective of the affected patient (NHS England, 2023).

In the physical harm category, the LFPSE organises the levels into no physical harm, low physical harm, moderate physical harm, severe physical harm, and fatal. The level descriptors are accompanied by decision criteria that consider, among other elements, the need for observation or minor treatment, the need for and duration of additional care, prolongation of hospitalisation, the need for immediate clinical intervention for preservation of life, impact on functional independence, repercussion on pre-existing conditions, permanence of the harm, probable reduction of life expectancy, and possible contribution of the incident to death. The low physical harm level has a cumulative logic, requiring the fulfilment of all the criteria defined for this level; the moderate and severe levels are attributed by the presence of at least one of the criteria specific to each level, which exceed, respectively, the limits defined for the immediately lower level; and the fatal level is applicable when, at the time of recording, the patient has died and the incident may have contributed to death, including pregnancy loss or stillbirth (NHS England, 2023).

In the psychological harm category, the LFPSE organises the levels into no psychological harm, low psychological harm, moderate psychological harm, and severe psychological harm, without a level corresponding to the fatal outcome. The source document makes explicit that the recording of psychological harm does not require a formal diagnosis nor assessment by a professional specialised in mental health, since the initial selection of the level of harm should reflect the information available at the time of recording and the judgement of the professional responsible for the record, and may be revised when new information becomes available. The level descriptors are accompanied by decision criteria that consider psychological distress, the need for and probable duration of treatment, repercussion on usual activities, impairment of independent living, new mental health diagnosis or significant worsening of a pre-existing condition, and expectation of recovery. Unlike low physical harm, the levels of low, moderate, and severe psychological harm are defined by the presence of at least one criterion specific to each level. The gradation between the levels occurs mainly through the intensity and expected duration of the repercussions: psychological harm of shorter duration and without persistent functional repercussion tends

to be framed within the low level; harm with the need for treatment or functional impact of less than six months guides classification as moderate; and harm with treatment, functional repercussion, or absence of expected recovery beyond six months guides classification as severe (NHS England, 2023).

The separation between physical and psychological harm is a structuring component of the material to be adapted. By recognising psychological outcomes as a category proper to the consequence of incidents, the classification expands the capacity for characterising harm and aligns with the literature that advocates its incorporation into systems of notification, classification, and learning from patient safety incidents (Pfeiffer *et al.*, 2025).

2.4 SETTING AND TARGET SYSTEM

The target health system will be the SUS, a public system that is decentralised, regionalised, and guided by the principles of universality, integrality, and equity (Paim *et al.*, 2011; Massuda *et al.*, 2023). The adaptation will seek to render compatible the classification originally developed in NHS England with the normative, terminological, and organisational context of the SUS, considering the heterogeneity of the RAS, the PNQSP, the PNSP, and the Notivisa. The study will be conducted remotely, with the participants of the adaptation and validation stages acting from different Brazilian regions, without ties to a specific health service.

2.5 CONSIDERATION OF THE PERSPECTIVE OF PATIENTS AND FAMILY MEMBERS

Although patients and family members do not participate in the stages of this study, the patient safety system in force in NHS England, including the PSIRF and the LFPSE, recommends their participation in the response to patient safety incidents. In coherence with this principle, and in addition to the publication directed at the scientific community, a synthesis of the results will be prepared in accessible language, intended for SUS users, including patients and family members, and for other interested parties, with the objective of favouring understanding about the study and its findings and of providing transparency to the process of adapting the classification to the SUS context.

2.6 PARTICIPANTS AND SELECTION CRITERIA

The participants will be defined by methodological stage and will include translators, back-translators, members of the committee for the review of the translated document, specialists for the content validation, and professionals for the face validation. The research team will be responsible for the methodological and operational conduct, comprising the

organisation of the source material, the preparation of the instruments, the coordination of the stages, the consolidation of the versions, the analysis of the contributions, the preparation of the feedback to the specialists between the Delphi rounds, and the systematic recording of decisions. It will also fall to the team to construct the matrix of normative and conceptual correspondence, select the pertinent Brazilian documents, systematise the comparative analyses, propose preliminary adaptive decisions, and carry out the version control that sustains the adapted version.

In the initial translation, two independent translators will be included, bilingual, with Brazilian Portuguese as their mother tongue and command of English: one with training and practice in the health field and prior knowledge of the ICPS, and another professional from the language field, without prior involvement with the object nor knowledge of the objectives of the classification. This composition, one translator with knowledge of the topic and another without prior familiarity with it, follows Beaton *et al.* (2000) and the ISPOR (Wild *et al.*, 2005), balancing conceptual precision, terminological adequacy, and linguistic naturalness. In the back-translation, two independent translators will be included, bilingual, with English as their mother tongue and command of Brazilian Portuguese, distinct from the initial translators and without access to the source document, so as to reduce biases. The review committee will be composed of the translators, the back-translators, a specialist in research methodology with experience in cross-cultural adaptation, and the research team.

Content validation will be carried out with the participation of seven specialists, intentionally selected by complementary competence profiles in public health, patient safety, quality management in health services, and mental health, all with prior experience in the SUS; the sizing of seven evaluators observes the recommendations of Lynn (1986) and of Polit, Beck, and Owen (2007), who recommend a group of six or more specialists for the adoption of the threshold of I-CVI ≥ 0.78 with adequate control of chance agreement. The inclusion of specific competence in mental health aims to strengthen the evaluation of the criteria relating to the psychological harm category, since it constitutes a harm category still poorly consolidated in the national incident notification systems.

Face validation will be conducted with eight professionals working in Patient Safety Centres (NSP), with experience in the analysis of adverse events and in the coordination of improvement actions arising from these events, and representation of different Brazilian regions. Eligibility will require prior experience in the SUS. Participation in the validation stages will occur only after formal agreement and signature of the Free and Informed Consent Form (TCLE).

2.7 STAGES OF THE STUDY

2.7.1 Initial translation

The source classification will be translated independently from English into Brazilian Portuguese by two bilingual translators, resulting in two initial versions (T1 and T2). The translator from the health field will prioritise the conceptual precision of the harm categories, the levels of harm, the level descriptors, and the decision criteria; the language professional will prioritise clarity, fluency, and naturalness. Each translator will record, in their own form, difficulties, uncertainties, and justifications for relevant terminological choices.

2.7.2 Synthesis of the translations

Versions T1 and T2 will be compared with each other and confronted with the source classification, identifying terminological divergences, differences in formulation, ambiguities, losses of meaning, and alternatives more suited to Brazilian Portuguese. From this analysis, the synthesis version (T12) will be prepared, by consensus between the research team and the translators, considering conceptual precision and linguistic adequacy. All decisions will be documented, with recording of the alternatives discussed, the selected option, and the respective justification.

2.7.3 Back-translation

Version T12 will be submitted to two independent back-translations into English (BT1 and BT2), with the purpose of verifying, in an indirect manner, whether the central meanings of the harm categories, the levels of harm, the level descriptors, and the decision criteria have been preserved. The back-translators will systematically record difficulties, uncertainties, and observations relevant to the evaluation of equivalence with the source material.

2.7.4 Committee review of the translated version

The committee review will analyse comparatively the source classification, versions T1, T2, and T12, the back-translations BT1 and BT2, and the previous methodological records. Each component of the classification, including harm categories, levels of harm, level descriptors, and decision criteria, will be appraised in terms of the semantic, idiomatic, experiential, and conceptual equivalences, by means of a structured form, in which each member will classify the degree of equivalence and indicate the need for adjustment; the agreement among the members and the comments will support the collegiate decision. Special attention will be given to the preservation of the original meaning and of the logical

structure of the decision criteria, including the requirement of fulfilment of all criteria in the low physical harm level and of at least one criterion in the other levels of harm.

Once discrepancies, ambiguities, omissions, shifts of meaning, or insufficient formulations are identified, the committee may propose wording adjustments, resume previously discussed alternatives, or recommend new formulation, provided that conceptual equivalence with the source classification is preserved. The decisions will be recorded in a specific instrument, with indication of the analysed unit, the problem, the alternatives considered, the decision adopted, and the justification. At the end, the committee's consensus version will be produced, in Brazilian Portuguese.

2.7.5 Normative and organisational contextualisation to the SUS

While the semantic and idiomatic equivalences are verified above all in the previous linguistic stages (initial translation, synthesis, back-translation, and committee review), the committee's consensus version will be submitted to the normative and organisational contextualisation to the SUS, a stage that operationalises the verification of the conceptual and experiential equivalences, given the normative dependence of the criteria of the classification (section 2.2).

The research team will analyse each harm category, each level of harm, and the respective level descriptors and decision criteria, identifying correspondences with Brazilian legislation, regulations, sanitary guidelines, and technical documents. A matrix of normative and conceptual correspondence will be constructed, organised by harm category, level of harm, level descriptor, and decision criterion. For each level descriptor and respective decision criterion, the fields of the matrix presented in Table 2 will be filled in.

Table 2

Structure of the matrix of normative and conceptual correspondence: fields and respective content recorded for each level descriptor and decision criterion

MATRIX COMPONENT	CONTENT RECORDED FOR EACH DESCRIPTOR AND DECISION CRITERION
Normative correspondence	Existence or absence of legislation, regulation, sanitary guideline, or Brazilian technical document related to the descriptor or decision criterion
Sources identified	Identification of the corresponding Brazilian documents
Implications	Implications of the normative correspondence, or of its absence, for the adaptation of the passage
Proposed decision	Maintenance, modification, inclusion, suppression, or insertion of an explanatory note

Adapted wording	Adapted wording of the descriptor or of the decision criterion, when applicable
Technical justification	Technical grounding of the adaptive decision adopted

Source: prepared by the authors (2026).

The adaptive decisions will preserve conceptual equivalence with the source classification and, simultaneously, favour coherence with the normative, sanitary, and organisational framework of Brazilian public health. At the end, the pre-final version will be produced, accompanied by the matrix, to be forwarded to the specialists in the content validation.

2.7.6 Content validation using the Delphi method

Content validation will be conducted using the Delphi method, with the participation of seven specialists, with the purpose of obtaining structured, anonymous, and iterative judgement on the technical and conceptual adequacy of the adapted version. The specialists will receive, by electronic mail, the access link to a structured form on the Microsoft Forms platform, accompanied by the pre-final version of the classification and the matrix of normative and conceptual correspondence, containing the correspondences identified, the documents considered, the preliminary adaptive decisions, and their respective justifications.

The evaluation will be organised by harm category and by level of harm. For each level, the level descriptor and the respective decision criteria will be submitted for the appraisal of the specialists, so that the validation reaches not only the concrete conditions of classification, but also the statement that characterises each level. By way of illustration, in the severe psychological harm level, both the level descriptor and the respective decision criteria will be evaluated, such as distress with the need for treatment for more than six months, limitation of activities or of independent living for more than six months, and new diagnosis or worsening of a mental health condition without expected recovery within six months.

Each level descriptor and each decision criterion will be evaluated in terms of clarity, relevance, and conceptual adequacy. Additionally, in each level of harm, sufficiency will be evaluated, that is, whether the descriptor and the set of criteria characterise in a complete manner the corresponding level. The appraisal will use a four-point ordinal scale, with 1 = not adequate, 2 = needs major revision, 3 = adequate with minor revision, and 4 = adequate. Scores 3 and 4 will be considered concordant. Scores 1, 2, and 3 will require justification in an open field. Considering that the score 3 expresses the need for minor revision, the elements whose consensus is predominantly based on this category may be improved before

consolidation, even if they reach the established quantitative threshold, so that numerical agreement does not dispense with qualitative improvement.

The I-CVI will be calculated separately for each evaluated element and for each applicable attribute, that is, for each level descriptor and each decision criterion in terms of clarity, relevance, and conceptual adequacy, as well as for sufficiency in each level of harm. The use of the I-CVI for clarity, conceptual adequacy, and sufficiency follows extensions already employed in the content validation literature, maintaining relevance as the central attribute of this index. The elements with I-CVI = 1.00 in all attributes will be accepted directly. For the others, the minimum threshold of I-CVI ≥ 0.78 will be adopted. Considering the panel of seven specialists, this threshold will correspond, in practice, to the agreement of at least six evaluators. Should losses occur between the rounds and the minimum quorum of six specialists be maintained, the criterion will correspond to the agreement of at least five evaluators. The S-CVI/Ave will also be calculated, adopting as a reference a value ≥ 0.90 , and the modified kappa, as a complementary measure of agreement adjusted for chance, interpreted as excellent (> 0.74), good (0.60 to 0.74), or satisfactory (0.40 to 0.59), according to Polit, Beck, and Owen (2007).

The process will be conducted in up to two rounds. After the first round, the elements that reach the acceptance parameters and do not present comments indicative of substantive revision will be maintained. The others will be revised by the research team in light of the qualitative justifications presented by the specialists. In the second round, the specialists will receive the pending elements already revised, accompanied by an anonymised synthesis of the results of the previous round, the main justifications, the alterations carried out, and the decisions adopted. The re-evaluated elements will again be submitted to the calculation of the I-CVI and the modified kappa.

The response rate and any losses between the rounds will be monitored and reported. There will be no substitution of specialists after the start of the process. The team will assess the maintenance of the minimum quorum of six specialists for the application of the previously defined thresholds. Consensus per evaluated element, level descriptor, or decision criterion will be considered reached when the element presents I-CVI ≥ 0.78 , modified kappa in a range that is at least satisfactory, and absence of qualitative comments indicative of substantive revision. The S-CVI/Ave will be used as a global indicator of the content validity of the evaluated version, adopting a reference value ≥ 0.90 .

Should the absence of consensus persist after the second round, the final decision will fall to the research team, in an exceptional manner, by means of technical justification grounded in conceptual equivalence with the source classification, in coherence with the

Brazilian normative and organisational framework, and in the qualitative contributions of the specialists. All decisions will be recorded in a traceability matrix, containing, for each evaluated element, the indices obtained, the relevant qualitative contributions, the decision adopted, the alteration carried out, when applicable, and the respective justification. The version resulting from the content validation rounds will constitute the revised version to be forwarded to the face validation.

2.7.7 Face validation by professionals who may use the classification in their institutional practice

Face validation will be conducted with eight professionals working in SUS NSP, from the version revised after the content validation. The stage will have as its purpose to examine evidence related to the response process and to the adequacy of the classification for institutional use. The participants will receive, by electronic mail, the access link to a structured form on the Microsoft Forms platform, accompanied by the revised version of the classification.

The form will contemplate items on language, comprehension of the descriptors and decision criteria, distinction between physical harm and psychological harm, organisation of information, interpretability, and ease of identification of the levels of harm. An open field will also be made available for recording difficulties, perceived ambiguities, unclear terms, and suggestions for improvement.

The appraisal will use a four-point ordinal scale: 1 = not clear or not comprehensible; 2 = needs major revision; 3 = clear and comprehensible, with minor revision; and 4 = clear and comprehensible. Scores 3 and 4 will be considered concordant. Scores 1, 2, and 3 will require justification in an open field, in order to support the qualitative interpretation of the responses and the identification of the necessary adjustments.

For each evaluated item, the I-FVI will be calculated, corresponding to the proportion of participants who attribute a score of 3 or 4. A minimum cut-off point of $I-FVI \geq 0.80$ will be adopted. Considering eight participants, this criterion will correspond, in practice, to the agreement of at least seven evaluators. The S-FVI/Ave will also be calculated, as proposed by Yusoff (2019).

The modifications arising from this stage will be restricted, primarily, to adjustments of wording, presentation, and organisation of the classification, without alteration of the conceptual decisions consolidated in the content validation. Exceptionally, should convergent quantitative and qualitative evidence indicate a relevant risk of inadequate interpretation or

important difficulty of practical application, a more in-depth revision may be carried out, provided that it is technically justified and recorded.

All contributions of the participants and the decisions arising therefrom will be recorded in a traceability matrix, containing, for each evaluated item, the indices obtained, the relevant qualitative comments, the decision adopted, the corresponding justification, and the alteration carried out, when applicable. The version resulting from this stage will constitute the final version of the adapted classification.

2.8 DATA MANAGEMENT, PROTECTION, AND AVAILABILITY

The recording instruments will be prepared for each stage and developed within the Microsoft 365 ecosystem, being organised by type of product. The textual documents will be maintained in Microsoft Word and will comprise the successive versions of the classification (T1, T2, the synthesis version T12, the back-translations BT1 and BT2, the committee's consensus version, the pre-final version, the revised version, and the final version), in addition to the feedback document to the specialists, when there is a second Delphi round. The matrices and spreadsheets will be maintained in Microsoft Excel and will include the comparative spreadsheet of the synthesis, the committee review matrix, the matrix of normative and conceptual correspondence, the validation consolidation spreadsheets, intended for the calculation of the indices (I-CVI, S-CVI/Ave, and modified kappa; I-FVI and S-FVI/Ave), for the organisation of the qualitative contributions, and for the recording of the decisions, and the traceability matrix. The structured collection forms will be constructed on the Microsoft Forms platform and will encompass the appraisal of the review committee and the content and face validations, in addition to the forms for recording difficulties and justifications filled in by translators and back-translators; the responses of the validations will be exported to the consolidation spreadsheets in Excel.

The data will be managed in folders organised by stage, with standardised identification of the files, version control, and recording of origin, date, and person responsible for each alteration. Identifiable information of the participants will be kept separate from the analytical bases, replaced by alphanumeric codes and accessible only to the team. The files will be stored in Microsoft OneDrive, under the responsibility of the lead researcher, with access control by individual credentials and periodic backups, in compliance with the protocol approved by the Research Ethics Committee (CEP) and with the General Personal Data Protection Law (LGPD) (Brasil, 2018). The final version, the evaluation instruments, and the matrix of normative and conceptual correspondence will be made available in an open-

access repository at the end of the study; data that may allow the identification of the participants will not be shared.

2.9 DATA ANALYSIS

The data analysis will be conducted in a sequential, systematic, and integrated manner, combining comparative analysis of versions, documentary analysis of normative sources, quantitative analysis of the validity indices, qualitative analysis of the justifications and suggestions of the participants, and integrative synthesis of the methodological decisions. The central objective will be to demonstrate the equivalence of the adapted version in relation to the source classification, its coherence with the normative, terminological, organisational, and operational context of the Brazilian Unified Health System, and the evidence of content and face validity.

In the stages of initial translation, synthesis of the translations, back-translation, and committee review, the comparative analysis will encompass terminological divergences, ambiguities, losses of meaning, idiomatic inadequacies, conceptual inconsistencies, and any inadvertent alterations in the thresholds between the levels of harm. Each discrepancy will be recorded in a specific matrix, with description of the problem identified, alternatives considered, consensual decision, and corresponding technical justification.

The stage of normative and organisational contextualisation will be analysed by means of the matrix of normative and conceptual correspondence, with identification of convergences between the source classification and the national regulatory framework, gaps in regulation, terminological ambiguities, and needs for adjustment. The decisions arising from this analysis may involve maintenance, modification, inclusion, suppression, or insertion of explanatory notes, always with technical justification recorded.

In the content validation, the responses obtained on the ordinal scale will be described by absolute and relative frequencies, considering scores 3 and 4 as concordant. The I-CVI will be calculated separately for each evaluated element and for each applicable attribute, including clarity, relevance, conceptual adequacy, and sufficiency, when pertinent. With seven specialists, the cut-off point $I-CVI \geq 0.78$ will correspond, in practice, to the agreement of at least six evaluators; should losses occur between the rounds and the minimum quorum of six specialists be maintained, the criterion will correspond to the agreement of at least five evaluators. The S-CVI/Ave will also be calculated, adopting as a reference a value ≥ 0.90 , and the modified kappa, as a complementary measure of agreement adjusted for chance, interpreted according to the parameters defined in section 2.7.6.

In the face validation, the responses will also be described by absolute and relative frequencies, considering scores 3 and 4 as concordant. For each evaluated item, the I-FVI will be calculated, and the S-FVI/Ave will be obtained from the average of the respective I-FVI. With eight participants, the cut-off point $I-FVI \geq 0.80$ will correspond, in practice, to the agreement of at least seven evaluators. In this stage, the quantitative results will primarily guide adjustments of clarity, organisation, presentation, and usability, without automatic reopening of the conceptual decisions consolidated in the content validation.

The interpretation of the results will not be limited to the quantitative indices. The values obtained will be analysed together with the justifications of the specialists, the comments of the participating professionals, and the matrix of normative and conceptual correspondence, so as to distinguish wording problems, conceptual inconsistencies, normative gaps, practical difficulties of application, and technically justifiable divergences. Elements with satisfactory quantitative indices may be adjusted when the comments indicate a risk of mistaken interpretation. In an exceptional manner, elements that do not reach quantitative consensus after the planned rounds may be maintained by means of technical justification grounded in conceptual equivalence with the source classification, in coherence with the Brazilian framework, and in the qualitative contributions of the participants, with explicit recording in the traceability matrix.

The open contributions obtained in the content and face validation stages will be submitted to descriptive-interpretative qualitative analysis. The comments will be organised by evaluated item and coded independently by two researchers of the team, considering analytical categories related, among other aspects, to clarity, terminology, conceptual equivalence, applicability to the SUS, normative coherence, ambiguity, and usability. Coding divergences will be resolved by consensus and, should disagreement persist, by a third researcher, ensuring traceability between comments, decisions, and alterations carried out.

At the end of the validation stages, the quantitative and qualitative findings will be integrated into a matrix of methodological decision and traceability, which will record, for each descriptor, decision criterion, or evaluated item, the indices obtained, the relevant qualitative contributions, the team's decision, the technical justification, and the alteration carried out, when applicable. The final version will be consolidated with a view to the preservation of conceptual equivalence with the source material, of the consistency of the structure of harm categories, levels of harm, level descriptors, and decision criteria, as well as of coherence with the normative, terminological, organisational, and operational context of the SUS.

2.10 ETHICAL ASPECTS

The study will be conducted in compliance with Resolução CNS nº 466/2012 (Brasil, 2012) and other Brazilian regulations applicable to research with human beings. The project was submitted to and approved by the Research Ethics Committee with Human Beings of the Faculdade de Ciências da Saúde of the Universidade de Brasília, under CAAE nº 60244722.5.0000.0030 and Opinion nº 7.562.342. Participation will occur upon signature of the TCLE, with a guarantee of voluntariness, confidentiality of information, anonymity among the participants in the validation process, and the right to withdraw at any time, without any prejudice.

2.11 CURRENT STATUS AND TIMELINE

At the date of submission of this manuscript, the study is in the initial translation phase. It is estimated that the stages of initial translation, synthesis of the translations, back-translation, committee review, and normative and organisational contextualisation to the SUS will be completed in approximately four weeks, resulting in the pre-final version of the classification and the respective matrix of normative and conceptual correspondence. Subsequently, approximately three months are foreseen for the final stages: two months allocated to the content validation using the Delphi method, with up to two rounds, and to the face validation; and one month allocated to the integrated analysis of the results, the recording of decisions in a traceability matrix, and the consolidation of the final version of the adapted classification. The detailed timeline and any amendments to the protocol will be recorded on an open-access platform, preserving the version history.

3 DISCUSSION

It is assumed that the incorporation, into another national context, of a patient safety classification conceived in a particular health system is not reduced to linguistic translation. It is admitted, based on the methodological literature, that instruments and classifications whose criteria depend on contextual interpretation demand formal cross-cultural adaptation, capable of preserving the semantic, idiomatic, experiential, and conceptual equivalences between the source version and the adapted one (Guillemin; Bombardier; Beaton, 1993; Beaton *et al.*, 2000).

In the case of the levels-of-harm classification of NHS England, it is presumed that cross-cultural adaptation is necessary, since its decision criteria involve organisational, care, and normative dimensions that would demand interpretation in light of the SUS context. In Brazil, this need would be associated with a possible gap: the "degree of harm" field of

Notivisa resorts to semantically broad descriptors and does not differentiate physical from psychological harm, which could compromise analytical precision and the comparability of data (Cooper *et al.*, 2018).

A central aspect is to treat the object as an operational classification, and not as a psychometric scale. Being composed of harm categories, levels, descriptors, and decision criteria, without generating scores, its adaptation is sustained on evidence of content and response process validity, not on analyses of internal structure or relation with external variables (American Educational Research Association; American Psychological Association; National Council on Measurement in Education, 2014; Terwee *et al.*, 2018). This delimitation adjusts the design to the nature of the object and makes explicit the scope of the validity inferences.

The normative and organisational contextualisation to the SUS is the main differential of this protocol in comparison with strictly linguistic adaptations. The criteria of the source classification incorporate references to types of care, temporal parameters, levels of care intervention, and recording conditions that may have correspondence, implications, or limits of application in the normative, organisational, and care context of Brazilian public health. Brazil already has, moreover, an institutional record of the degree of harm in Notivisa, which should be considered so that the adapted version dialogues with the practice in force and grounds, in a coherent manner, any recommendations for improvement. Transposing the criteria of the source document without prior examination of their normative, organisational, and terminological compatibility would preserve the form of the original classification, but would compromise its interpretive consistency and its practical applicability.

The Brazilian experience with the London Protocol illustrates the challenges of incorporating methods conceived in other health systems without formally described and publicly available cross-cultural adaptation. In Brazil, the method is employed above all in the analysis of incidents that resulted in death and of never events (Agência Nacional de Vigilância Sanitária, 2025; Agência Nacional de Vigilância Sanitária, 2026), but its application occurs in a normative context distinct from that in which it was developed. One example is the absence, in the Brazilian legal order, of a specific and operationally equivalent legal duty to the British Duty of Candour, which mandates open communication with patients and family members following serious adverse events (Care Quality Commission, 2025; Quick, 2022). This normative difference may generate uncertainties as to the operationalisation of components of the method that depend on formalised practices of transparency, communication, and involvement of the people affected, favouring interpretive doubts and

variations in the conduct of these practices in Brazil, including in the SUS. Such asymmetry reinforces the need for structured adaptation processes.

The distinction between physical harm and psychological harm, incorporated by the LFPSE of NHS England, represents a relevant advance in the gradation of harm associated with patient safety events and aligns with international efforts to render visible forms of harm that have historically been neglected (World Health Organization, 2024; Pfeiffer *et al.*, 2025). In a conceptual framework developed in oncology, Dreismann *et al.* (2025) define preventable psychological harm as that arising from actions or omissions in interactions with the health system, including communication failures, lack of respect, and inadequate organisational policies, which deviate from patient-centred care and may negatively affect the well-being and health behaviour of patients and family members. The proposal seeks to render measurable, analysable, and preventable harm that is frequently invisible in care practice.

In the SUS, this category of harm is not yet established in the instruments and processes for responding to patient safety incidents. Its adaptation, therefore, is not a mere stage of conceptual equivalence, but an opportunity to introduce, in a structured and methodologically grounded manner, an aspect still insufficiently contemplated in the national classification system, which justifies the inclusion of mental health specialists in the content validation.

The protocol starts from the premise that the structural and logical particularities of the source material that sustain the fidelity of the adaptation should be preserved, whenever possible. The research team intends, thus, to maintain the asymmetry between the five levels of physical harm and the four of psychological harm, without a fatal level in the latter, and the requirement of all criteria in the low physical harm level, in contrast to at least one criterion in the other levels. These decisions will be submitted to the appraisal of the specialists in the content validation using the Delphi method and may be adjusted should there be technical consensus as to the need for adaptation to the normative, terminological, and operational context of the SUS.

The choice of the Delphi method is justified by the need for structured, anonymous, and iterative judgement by specialists on criteria whose interpretation is sensitive to context (Hasson; Keeney; McKenna, 2000). Its strength, in this protocol, lies in the mixed reading: the quantification through indices with thresholds defined a priori confers objectivity, while the requirement of justification for the scores that signal revision ensures that the values are interpreted in light of the qualitative reasons of the evaluators (Polit; Beck; Owen, 2007).

This mixed reading articulates quantitative results, qualitative justifications, and a traceability trail of decisions, allowing wording problems to be distinguished from conceptual

inconsistencies, normative gaps, and technically justifiable divergences, and expanding the robustness and reproducibility of the process. Face validation with NSP professionals examines evidence of the response process: clarity, comprehensibility, organisation, interpretability, and usability, a decisive dimension for the routine application of the classification and coherent with the operational nature of the object (Yusoff, 2019).

Transparency and reproducibility are reinforced by the prior registration of the protocol in an open-access repository, with a persistent identifier, and by adherence to consolidated reporting references: the good practices of the ISPOR and the guidelines of Sousa and Rojjanasrirat for the adaptation, the CREDES for the conduct and reporting of the Delphi rounds, and the recommendations of COSMIN insofar as applicable to a non-psychometric object (Wild *et al.*, 2005; Sousa; Rojjanasrirat, 2011; Jünger *et al.*, 2017; Terwee *et al.*, 2018). Added to the auditable recording of decisions at all stages, this set permits external scrutiny of the path that sustains the adapted version.

The composition of the participants of the validation stages is likewise anchored in the methodological literature on content validation, the Delphi method, and face validation (Hasson; Keeney; McKenna, 2000; Polit; Beck; Owen, 2007; Yusoff, 2019). The selection of specialists and of professionals who may use the classification in their institutional practice, with prior experience in the SUS and originating from different Brazilian regions, favours the pertinence and applicability of the decisions to the target context.

The adapted version should be understood as an initial stage of a broader agenda for the qualification of patient safety in the RAS. Since the establishment of the PNSP, advances have been observed in the implementation of computerised notification systems and in the expansion of the use of Notivisa, indicative of greater maturity of the recording culture (Maia *et al.*, 2018; Faustino *et al.*, 2021; Villar; Martins; Rabello, 2021). This increase makes the qualification of the harm classification even more relevant, since more precise data more robustly sustain the prioritisation of analyses, the allocation of efforts, and the definition of improvement actions proportionate to the risk (Cooper *et al.*, 2018). The study is, moreover, opportune in light of recent milestones that reposition the person and safety at the centre of the system, such as the Estatuto dos Direitos do Paciente and the PNQSP, which reinforce the need for clearer and more consistent instruments to define the harm resulting from incidents (Brasil, 2026a; Brasil, 2026b).

Some limitations must be acknowledged. The selection of the specialists and of the professionals who may use the classification in their institutional practice is intentional and of limited size. This characteristic, added to the absence of direct participation of patients and family members in the judgement, may restrict the generalisation of the findings;

nevertheless, the form of involvement of these people is incorporated as an object of discussion in the validation stages. Although it contemplates regional diversity and multiprofessional competence, the design does not fully encompass the heterogeneity of care, normative, and organisational contexts of the SUS, so that the adaptive decisions may predominantly reflect the institutional experiences represented by the participants, which recommends caution in generalisation to very distinct scenarios. Such limitations are inherent to cross-cultural adaptation processes (Beaton *et al.*, 2000; Alavi; Le Lagadec; Cleary, 2026) and reinforce the pertinence of subsequent stages of evaluation of the classification in different contexts of the RAS.

Finally, the operational nature of the object delimits the scope of the validity inferences, which do not contemplate evidence of internal structure or of relation with external variables. The adapted version is tied, moreover, to a specific date and version of the source document, whose subsequent updates will only be incorporated upon new documented methodological deliberation.

By proposing a methodologically structured adaptation, instead of the direct incorporation of an international classification, this study intends to contribute in two dimensions. On the methodological plane, it seeks to reinforce rigour in the adaptation of operational harm classifications for systems with a normative and organisational framework distinct from that of origin, proposing a replicable path that integrates cross-cultural adaptation, normative contextualisation, and contemporary validity evidence. On the care and systemic plane, it adds to the efforts for the qualification of safe care in the SUS, by favouring more comparable data, responses proportionate to the different types and levels of harm, and the strengthening of learning from incidents. The main strengths and limitations of the protocol are synthesised in Table 3.

Table 3

Main strengths and limitations of the study

STRENGTHS
This study protocol combines a consolidated reference of cross-cultural adaptation (Beaton <i>et al.</i> ; ISPOR; Sousa and Rojjanasrirat) with a contemporary framework of validity evidence, conferring rigour and reproducibility to the process.
The normative and organisational contextualisation to the SUS, operationalised by a correspondence matrix, is a differential in comparison with strictly linguistic adaptations.
The content validation, using the Delphi method, and the face validation are interpreted in a mixed manner, integrating quantitative indices with qualitative justifications and a documented path of decisions.
LIMITATIONS
As this is a classification of the level of harm, and not a psychometric instrument, no evidence of internal structure or of relation with external variables is produced, which delimits the scope of the validity inferences.

The choice of the specialists and of the professionals who may use the classification in their institutional practice is intentional and of limited size, without the direct participation of patients, which may restrict the generalisation of the findings.

Source: prepared by the authors (2026).

4 CONCLUSION

This protocol outlines the methodological path for the translation, cross-cultural adaptation, and validation, into Brazilian Portuguese, of the classification of levels of harm associated with patient safety events published by NHS England, oriented towards obtaining a version conceptually equivalent to the original and compatible with the normative and organisational context of the SUS. By stratifying the physical and psychological dimensions of harm and by offering more structured decision criteria for the attribution of the levels, it is expected that the validated version will qualify the information produced in notification systems, favour monitoring and organisational learning, and sustain more proportionate and transparent responses to patient safety events, contributing to the strengthening of the safety culture in the SUS.

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THE NORMATIVE INCONSISTENCY IN THE REPRESSION OF GENDER QUOTA FRAUD: THREE DOGMATIC ANTINOMIES IN THE JURISPRUDENTIAL CONSTRUCTION OF THE SUPERIOR ELECTORAL COURT

A INCONSISTÊNCIA NORMATIVA NA REPRESSÃO À FRAUDE À COTA DE GÊNERO: TRÊS ANTINOMIAS DOGMÁTICAS NA CONSTRUÇÃO JURISPRUDENCIAL DO TRIBUNAL SUPERIOR ELEITORAL

LA INCONSISTENCIA NORMATIVA EN LA REPRESIÓN DEL FRAUDE A LA CUOTA DE GÉNERO: TRES ANTINOMIAS DOGMÁTICAS EN LA CONSTRUCCIÓN JURISPRUDENCIAL DEL TRIBUNAL SUPERIOR ELECTORAL



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ABSTRACT

This article examines three structural normative inconsistencies in the legal regime for the repression of gender quota fraud, as constructed by the Brazilian Superior Electoral Court through Precedent No. 73 and Resolution No. 23,735/2024. The first antinomy concerns the limits of the Court's regulatory power: Article 105 of Law No. 9,504/1997 and Articles 1, sole paragraph, and 23, IX, of the Electoral Code authorise the issuance of instructions for the faithful execution of electoral legislation but prohibit innovation in substantive law, a limit strained by the dispensation of the subjective element in Article 8, § 4, of Resolution No. 23,735/2024 and by the open-textured typification consolidated in Precedent No. 73. The second antinomy concerns the judicial creation of a sanctioning modality not codified in statute: the cancellation of the Statement of Party Acts Compliance (DRAP) through Electoral Judicial Investigation Action and Action for the Annulment of Elective Mandate, with material effects of annulling the proportional slate, recalculating electoral and party quotients, and attributing eight-year ineligibility. The third antinomy reveals an internal contradiction within the jurisprudence itself: the political party is held to lack passive standing in AIJE proceedings, yet the DRAP (the legal act being cancelled) is held by the party. The article frames these three tensions in dialogue with the doctrine of the executive regulation, with the principle of legality of electoral sanctions, and with substantive due process, and argues that the normalisation of the current regime requires, at minimum, legislative mediation.

Keywords: Gender Quota Fraud. TSE Regulatory Power. Precedent No. 73. TSE Resolution No. 23,735/2024. DRAP Cancellation.

RESUMO

Este artigo examina três inconsistências normativas estruturais no regime jurídico de repressão à fraude à cota de gênero, conforme construído pelo Tribunal Superior Eleitoral por meio da Súmula nº 73 e da Resolução nº 23.735/2024. A primeira antinomia diz respeito aos limites do poder regulamentar da Corte: o art. 105 da Lei nº 9.504/1997 e os arts. 1º, parágrafo único, e 23, IX, do Código Eleitoral autorizam a edição de instruções para a fiel

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execução da legislação eleitoral, mas vedam a inovação no direito material, limite tensionado pela dispensa do elemento subjetivo no art. 8º, § 4º, da Resolução nº 23.735/2024 e pela tipificação aberta consagrada na Súmula nº 73. A segunda antinomia diz respeito à criação pretoriana de modalidade sancionadora não tipificada em lei: a cassação do Demonstrativo de Regularidade de Atos Partidários (DRAP) por meio de Ação de Investigação Judicial Eleitoral e de Ação de Impugnação de Mandato Eletivo, com efeitos materiais de anulação da chapa proporcional, retotalização dos quocientes eleitoral e partidário e atribuição de inelegibilidade octenal. A terceira antinomia revela contradição interna na própria jurisprudência: o partido político é considerado parte ilegítima para figurar no polo passivo da AIJE, mas o DRAP, ato jurídico que se cassa, é titularizado pelo partido. O artigo articula essas três tensões em diálogo com a doutrina do regulamento de execução, com o princípio da tipicidade das sanções eleitorais e com o devido processo legal substancial, e sustenta que a normalização do regime atual exige, no mínimo, mediação legislativa.

Palavras-chave: Fraude à Cota de Gênero. Poder Regulamentar do TSE. Súmula 73. Resolução TSE Nº 23.735/2024. Cassação de DRAP.

RESUMEN

Este artículo examina tres inconsistencias normativas estructurales en el régimen jurídico de represión del fraude a la cuota de género, según construido por el Tribunal Superior Electoral mediante la Súmula nº 73 y la Resolución nº 23.735/2024. La primera antinomia se refiere a los límites del poder reglamentario de la Corte: el art. 105 de la Ley nº 9.504/1997 y los arts. 1º, párrafo único, y 23, IX, del Código Electoral autorizan la edición de instrucciones para la fiel ejecución de la legislación electoral, pero vedan la innovación en el derecho material, límite tensionado por la dispensa del elemento subjetivo en el art. 8º, § 4º, de la Resolución nº 23.735/2024 y por la tipificación abierta consagrada en la Súmula nº 73. La segunda antinomia se refiere a la creación pretoriana de una modalidad sancionadora no tipificada en ley: la casación del Demostrativo de Regularidad de Actos Partidarios (DRAP) mediante la Acción de Investigación Judicial Electoral y la Acción de Impugnación de Mandato Electivo, con efectos materiales de anulación de la lista proporcional, retotalización de los cocientes electoral y partidario y atribución de inelegibilidad octenal. La tercera antinomia revela contradicción interna en la propia jurisprudencia: el partido político es considerado parte ilegítima para figurar en el polo pasivo de la AIJE, pero el DRAP, acto jurídico que se casa, es titularizado por el partido. El artículo articula estas tres tensiones en diálogo con la doctrina del reglamento de ejecución, con el principio de tipicidad de las sanciones electorales y con el debido proceso legal substancial, y sostiene que la normalización del régimen actual exige, como mínimo, mediación legislativa.

Palabras clave: Fraude a la Cuota de Género. Poder Reglamentario del TSE. Súmula 73. Resolución TSE Nº 23.735/2024. Casación de DRAP.

1 INTRODUCTION

The gender quota policy, set out in Article 10, § 3, of Law No. 9,504/1997, as amended by Law No. 12,034/2009, represents one of the most significant affirmative actions of Brazilian electoral law. Conceived to correct the historical under-representation of women in spaces of political power, the rule requires each party or federation to fill a minimum of thirty per cent and a maximum of seventy per cent of candidacies for each gender.

The formulation appears, at first sight, strictly quantitative, but as institutional experience has demonstrated, it has become the axis of one of the most innovative and most dogmatically strained jurisprudential constructions of the Superior Electoral Court over the last two decades, with effects that go beyond the mere reading of the percentage and reach the very sanctioning architecture of the electoral system.

The judicialisation of the matter presented the Superior Electoral Court with a dogmatically novel problem: the merely formal compliance with the minimum percentage, by registering female candidacies without any genuine intention to compete, empties the purpose of the affirmative policy and converts the protective rule into an instrument of simulation.

The jurisprudential response — developed in the case of José de Freitas/PI (REspe No. 1-49/PI, Rapp. Min. Henrique Neves da Silva, judged on 4 August 2015), deepened in the case of Valença do Piauí (REspe No. 193-92/PI, Rapp. Min. Jorge Mussi, judged on 17 September 2019) and in the case of Jacobina/BA (AgR-AREspE No. 0600651-94, drafter of the judgment Min. Alexandre de Moraes, judged on 10 May 2022), regulated by TSE Resolution No. 23,735 of 27 February 2024, and finally consolidated in Precedent No. 73, approved on 16 May 2024 — constructed, in little less than a decade, an entire regime for the identification, ascertainment and repression of so-called fictitious candidacy.

This construction, although indispensable to preserving the constitutional programme of gender equality in politics, was carried out from the top down: the Courts defined the contours of the wrongdoing, the effects of a successful claim, the evidentiary regime and the applicable procedure, even before the National Congress had provided, in formal law, for each of these elements. This precedence of jurisprudence over statute is, in the sanctioning field, more than an institutional curiosity; it is, as will be sought to be demonstrated, a source of structural dogmatic tensions that the present article proposes to examine.

The present article draws on the theoretical and empirical findings of the master's research conducted by the author at the Instituto Brasileiro de Ensino, Desenvolvimento e Pesquisa (IDP), in the context of the jurisprudential analysis of the judgments of the Tribunal

Regional Eleitoral de Goiás between 2022 and 2025, in order to deliberately shift the focus of the discussion.

That research examined, above all, the evidentiary problem of quota fraud: the centrality of circumstantial evidence, the plurality of decisional standards, inferential convergence as a criterion substituting direct proof and the impossibility of rigid uniformisation in the face of factual heterogeneity.

Here, the proposal is to shift the analytical axis from evidence to normativity: to investigate whether the regime constructed by the Superior Electoral Court, in its formal structure, satisfies the requirements of strict legality, sanctioning typicity and due process that govern the electoral repressive system. The question, in other words, is no longer how fraud is proven, but whether the regime that punishes fraud is founded on an adequate normative basis.

Three inconsistencies are examined. The first concerns the limits of the regulatory power of the Superior Electoral Court. Article 105 of Law No. 9,504/1997 authorises the issuance of instructions for the faithful execution of the law, without restricting rights or establishing sanctions distinct from those provided for in this Law — a formula reiterated in Articles 1, sole paragraph, and 23, item IX, of the Electoral Code. The question is whether Resolution No. 23,735/2024, by dispensing with the subjective element of fraud (Article 8, § 4), and Precedent No. 73 itself, by consolidating an open-textured type of wrongdoing, have not exceeded that limit.

The second has as its object the creation, by jurisprudential construction, of a sanctioning modality not codified in statute: the cancellation of the Statement of Party Acts Compliance, with material effects on the proportional slate, on the votes attributed to candidates considered individually and on the elected candidate, through Electoral Judicial Investigation Action and Action for the Annulment of Elective Mandate, actions whose legal basis did not provide for this effect, and whose procedural architecture was designed for distinct purposes.

The third, finally, exposes an internal logical contradiction within the system itself: the consolidated jurisprudence of the Superior Electoral Court holds that the political party does not have standing to figure as a defendant in AIJE proceedings; however, the DRAP (the legal asset that is cancelled) is, indisputably, a party act. In the final analysis, the one who could not be a party — and whose procedural position was never consolidated in the original legal relationship — is punished.

The central hypothesis of this work is that these three inconsistencies are not contingent, do not arise from isolated errors or drafting imprecisions that could be corrected

by mere interpretative rectification, but are structural: they arise from a legislative deficit that has been supplied by jurisprudential and regulatory construction of such magnitude that, at the limit, it causes the dogmatic distinction between execution and innovation in electoral sanctioning law to collapse.

What is maintained here does not deny the material legitimacy of combating gender quota fraud; on the contrary, it proceeds from the conviction that affirmative action must be effectively protected, on pain of becoming a dead letter, but it affirms that the form of this combat, in its current state, compromises the coherence of the system and demands, urgently, the intervention of the legislator. The argument is therefore twofold: it recognises the necessity of the combat and questions the formal sufficiency of the instruments.

2 THE QUOTA POLICY AND THE EMERGENCE OF FRAUD AS A LEGAL-ELECTORAL CATEGORY

2.1 FROM FACULTATIVE RESERVATION TO MANDATORY FILLING: THREE NORMATIVE CYCLES

The Brazilian regime of gender quotas has passed through three successive normative cycles, an understanding of which is decisive for the examination of the dogmatic antinomies that follow. The first was inaugurated by Law No. 9,100/1995, which reserved a minimum percentage of female candidacies for the 1996 municipal elections, and continued with the original wording of Law No. 9,504/1997, which established the rule of reservation (not yet of filling) of a minimum of thirty per cent of the seats for candidacies of each gender.

The difference is not merely terminological, but dogmatically decisive: the original wording authorised the party to reserve seats that did not need to be occupied, a hypothesis rapidly converted into a generalised institutional practice. The low effectiveness of the model is documented in the official data, since in the subsequent proportional elections the female presence on the slates fluctuated below the minimum percentage legally reserved, without this generating, in most cases, any relevant legal consequence, because the reservation was itself, to a large extent, an act of symbolic compliance.

The second cycle opened with Law No. 12,034/2009, which replaced the verb 'reserve' with 'fill', imposing on parties the effective obligation to include the minimum percentage of female candidacies. It was precisely in this cycle, between 2009 and 2016, that the phenomenon today known as fictitious candidacy was developed: faced with the requirement of filling, parties began to register women without any real expectation of competing, with the sole objective of formally complying with the quota and avoiding the rejection of the collective registration of the slate.

The pathology is therefore structurally dependent on the normative design: it was the legal regime that created the conditions for its own fraud. The migration from reservation to filling, without the concomitant establishment of mechanisms for materially assessing the effectiveness of the candidacy, opened the flank that party engineering promptly exploited. In this sense, quota fraud is not a contingent deformation of the rule, but a rational response by political actors to the regulatory incentive, a diagnosis that conditions the entire subsequent dogmatic discussion.

The third cycle is jurisprudential and still ongoing. From the judgment of REspe No. 1-49/PI, in August 2015, the Superior Electoral Court recognised, for the first time, that the concept of electoral fraud is open-textured and may reach fraud against the law, a premise that subsequently enabled the application of the figure to the merely formal compliance with the minimum percentage.

The case of José de Freitas/PI became a leading case and established the paradigm of substantive (not merely arithmetic) examination of compliance with the quota. From then on, the construction was progressive and cumulative: the case of Valença do Piauí (REspe No. 193-92/PI, Rapp. Min. Jorge Mussi, judged in 2019) fixed the thesis of the collective cancellation of the Statement of Party Acts Compliance as a consequence of fraud; the case of Jacobina/BA (AgR-AREspE No. 0600651-94, drafter of the judgment Min. Alexandre de Moraes, judged in 2022) refined the circumstantial criteria that allow, at the evidentiary level, the inference of fraud — zero or negligible votes for the female candidates, accountability statements with identical financial movements, absence of effective campaign acts; TSE Resolution No. 23,735 of 27 February 2024 provided for electoral wrongdoings and positivated the indicia in its Article 8; and Precedent No. 73, approved in the administrative session of 16 May 2024, consolidated the understanding under a deliberately open-textured formula.

Each of these stages added regulatory layers onto the static legal basis of Law No. 9,504/1997, without the legislator having, at any moment, intervened to endorse or adjust the product of the jurisprudential construction.

2.2 THE LEGAL CATEGORY OF QUOTA FRAUD AND THE CURRENT REGIME

Gender quota fraud, as it is understood today, presents an open-textured type, configured from the contextual articulation of indicia, and not from subsumption to a typical and closed legal description.

TSE Resolution No. 23,735/2024 systematised, in Article 8, §§ 2 and 3, the circumstantial criteria consolidated by the Court's jurisprudence: zero or derisory votes for

the female candidates, accountability statements with identical financial movements, absence of effective campaign acts for their own benefit (§ 2), and party negligence revealed by the legal unviability of the candidacy, inertia in remedying documentary deficiencies or absence of replacement of a candidate whose registration was rejected (§ 3).

These criteria, according to the regulatory construction itself, are not cumulative, do not operate as absolute presumptions and do not constitute a *numerus clausus* list; they function as an open catalogue whose contextual combination authorises the inference of the teleological distortion of the rule. The model is therefore deliberately flexible, this flexibility being, at the same time, its greatest empirical virtue and its greatest dogmatic fragility.

Paragraph 4 of Article 8, however, introduced an innovation of great magnitude in providing that, for the characterisation of fraud, the teleological distortion is sufficient, dispensing with the demonstration of the subjective element (*consilium fraudis*). Fraud ceases to be a wrongdoing of conduct, in which the agent's awareness and will are assessed, to become a wrongdoing of result, it being sufficient to verify objectively the divergence between the normative programme and the state of affairs produced, breaking with the civil doctrine of fraud, which required at least the *scientia fraudis*. Whether this material redefinition is compatible with the regulatory and precedential instruments employed is the question examined in section 3.

In terms of legal consequences, fraud produces material effects expressly provided for in Article 8, § 5, of TSE Resolution No. 23,735/2024 and in Precedent No. 73. According to the regulatory text, gender quota fraud entails the cancellation of the diploma of all elected female candidates and of all elected candidates, the invalidation of the list of candidacies of the party or federation that availed itself of it and the annulment of nominal and party votes, with the consequences provided for in the caput of Article 224 of the Electoral Code.

In synthetic terms, three material effects accumulate: the cancellation of the slate's proportional DRAP, with the annulment of all votes attributed to the party or federation in the constituency; the recalculation of the electoral and party quotients, with possible alteration of the picture of the elected in other party associations; and ineligibility, for eight years, of those responsible for the fraud, such as party leaders, candidates of the slate in collusion and, in controversial hypotheses, the instrumentalised candidate herself, although the more recent jurisprudence, in dialogue with Law No. 14,192/2021, tends to recognise the latter as a victim of the wrongdoing.

It is precisely the design of this regime (open-textured type, dispensation of the subjective element and sanctions of high material gravity) that makes the examination of the three antinomies that follow pertinent. The question is not whether combating fraud is

legitimate (it is), but whether its legal-formal design satisfies the requirements of strict legality of sanctions, material typicity of the wrongdoing and structured adversarial procedure.

3 FIRST ANTINOMY: THE LIMITS OF THE REGULATORY POWER OF THE SUPERIOR ELECTORAL COURT

3.1 THE LEGAL REGIME OF INSTRUCTIONS: ARTICLE 105 OF LAW NO. 9,504/1997 AND THE ELECTORAL CODE

The Superior Electoral Court exercises a peculiar regulatory function, distinct from the classic administrative regulation. Unlike the regulation of the Head of the Executive (Article 84, IV, of the Constitution), aimed at making executable a law already in force on matters of the organisation of the administration, the instructions of the Electoral Justice constitute a *sui generis* normative category, exercised by a Court that accumulates administrative, normative and jurisdictional functions.

This peculiarity does not expand, but restricts the limits of the regulatory power: the Court that issues the regulation will also be the one that applies it in contentious proceedings, which makes restraint within strict bounds all the more necessary.

The main legal landmarks of this function are three. Article 1, sole paragraph, of the Electoral Code (Law No. 4,737/1965) determines that the Superior Electoral Court shall issue instructions for the faithful execution of the Code; Article 23, IX, of the same statute lists among the private competences of the Court the issuance of the instructions it deems convenient for its execution; and the third, most relevant to the subject, is Article 105 of Law No. 9,504/1997:

Until the 5th of March of the election year, the Superior Electoral Court, in accordance with the regulatory nature and without restricting rights or establishing sanctions distinct from those provided for in this Law, may issue all the instructions necessary for its faithful execution, having previously heard, in public hearing, the delegates or representatives of the political parties. (BRASIL, 1997, art. 105)

The joint reading of the three provisions reveals four structural limits that merit analytical emphasis. The first is the temporal limit, namely, the issuance until 5 March of the electoral year, a deadline intended to avoid regulatory innovations in proximity to the poll. The second is the procedural limit, being the prior hearing of the parties in public hearing, a requirement that confers on the process of drafting the instructions an atypical participatory dimension, distinct from the purely unilateral regulation. The third is the material limit expressed in the prohibition on restricting rights or establishing sanctions distinct from those provided for in the law, a formula which, on pain of becoming an empty word, must be read

in a robust sense, reaching not only the creation of literally new sanctions, but also the redefinition of the constitutive elements of existing sanctions. The fourth, finally, is the teleological limit, considering that the instructions exist for the faithful execution of the law, an expression that presupposes a pre-existing legal content to be executed, and not a normative space to be filled by the autonomous construction of the Court.

It is an executive regulation, and not an autonomous one: its function is to make executable what the law has already provided (deadlines, forms, rites, formal requirements), not to introduce new substantive provisions. The 1988 Constitution expressly prohibited autonomous regulation in matters reserved to statute, and the electoral system, by its proximity to fundamental political rights, is a matter reserved to formal law, when not to complementary law (the case of the hypotheses of ineligibility of Article 14, § 9, of the Constitution).

3.2 THE LEGAL NATURE OF INSTRUCTIONS: EXECUTIVE REGULATION, NOT INNOVATION

The consolidated administrative doctrine — *Bandeira de Mello, Carvalho Filho* — converges in the diagnosis that the executive regulation cannot innovate in the legal order in matters reserved to statute, on pain of violation of the principle of the separation of powers (Article 2 of the Constitution) and the principle of legality (Article 5, item II).

The prohibition takes on even more rigid contours when the object of regulation involves sanctioning law: in the electoral field, the cancellation of registration, the cancellation of the diploma and the declaration of ineligibility are consequences of high material gravity, which affect the core of fundamental political rights, above all the right to be voted for. From the historical dialogue between the tax and criminal doctrines results the consolidation of a broad principle of sanctioning legality, applicable to all law that produces a restriction of fundamental rights, a principle that, in the electoral field, finds direct expression in Article 105 of Law No. 9,504/1997.

The consequence of this doctrinal convergence is direct: the Superior Electoral Court, in issuing instructions on the basis of Article 105 of Law No. 9,504/1997 or Articles 1, sole paragraph, and 23, IX, of the Electoral Code, exercises a derived and subordinate function. It cannot create new sanctioning types, the typification of electoral wrongdoings being a matter reserved to statute. It cannot dispense with constitutive elements of already existing types — the material redefinition of the type exceeds the executory function. It cannot redefine the evidentiary regime so as to alter the regime of liability — for the alteration of the

evidentiary standard, when substantive, is equivalent to the alteration of the very definition of the wrongdoing.

These three prohibitions operate jointly and form the perimeter of what can and cannot be regulated by the Court without legislative mediation. The fact that the Electoral Justice accumulates administrative and jurisdictional functions does not authorise, it must be repeated, the relaxation of this rule; on the contrary, it demands special caution.

There is, however, a doctrinal argument to the contrary, which needs to be addressed. It is maintained, with some support in the jurisprudence of the Superior Electoral Court itself, that the regulatory function of the Court would have an amplitude superior to the classic executive regulation, by reason of its mixed institutional nature, administrative and jurisdictional at the same time.

This thesis of institutional specificity finds acceptance in some judgments that recognised the Electoral Justice a wider regulatory space than that granted to the regulation of the Executive Power. The objection is not insuperable: even if a greater amplitude is admitted in strictly procedural matters (forms, deadlines, rites), this amplitude does not extend, without legislative mediation, to the terrain of the material definition of sanctioning wrongdoings. Institutional specificity is not a general clause for the relaxation of strict legality; it is, at most, a justification for some deference in operational matters.

3.3 THE DISPENSATION OF THE SUBJECTIVE ELEMENT (RESOLUTION NO. 23,735/2024, ARTICLE 8, § 4)

It is precisely at this point that the first antinomy manifests itself most clearly. Resolution No. 23,735/2024 provided, in Article 8, § 4, that for the characterisation of gender quota fraud, the teleological distortion is sufficient, dispensing with the demonstration of the subjective element (*consilium fraudis*), and Precedent No. 73, in the same sense, provides that the sanction reaches the party and the candidates linked to it regardless of proof of participation, knowledge or acquiescence.

Before the Resolution, the dominant doctrine required the *consilium fraudis*, the conscious arrangement between agents for the merely formal compliance with the percentage. From it, the teleological distortion objectively ascertained by the *indicia* is sufficient. This dispensation may be supported by robust empirical reasons, but it is, without doubt, an alteration of dogmatic foundations that needs to face the test of the adequate normative form.

The central dogmatic question is: can the Superior Electoral Court, in the exercise of the regulatory power of Article 105, suppress by instruction an element that the classic

doctrine considered constitutive of the wrongdoing? To suppress the subjective element is, in the final analysis, to redefine the type, transforming it from a wrongdoing of conduct into a wrongdoing of result. This redefinition is not executory, but constitutive and, for this reason, exceeds the limits of the executive regulation, a difference between executing and constituting that has been rigorously preserved in other fields of sanctioning law, such as the tax and the criminal.

It is not intended thereby to maintain the invalidity of Resolution No. 23,735/2024 or to propose its challenge. The construction is, from a material point of view, defensible, given that the requirement of the subjective element, in practice, made the configuration of fraud unviable (because the specific intent, in candidacies whose direct agents are people close to the candidate and who never admit collusion, was a practically insuperable obstacle) and rendered the affirmative policy a dead letter. What is maintained is more modest, given that the form of the response (regulatory instruction) is not compatible with the magnitude of the dogmatic modification promoted. The constitutionally adequate path would be legislative mediation, with amendment of Article 10, § 3, of Law No. 9,504/1997 or an express provision in Complementary Law No. 64/1990 making it explicit that fraud is configured objectively. The absence of this mediation produces the dogmatic tension that is examined.

3.4 PRECEDENT NO. 73, ARTICLE 926 OF THE CPC AND THE PROBLEM OF STABILISATION

An additional argument, which reinforces the first antinomy, arises from Precedent No. 73 of the Superior Electoral Court itself, which states, in synthesis, that quota fraud is configured when the facts and circumstances of the concrete case authorise the recognition of the teleological distortion of the rule.

The statement is deliberately open-textured and this openness is, in part, an inevitable consequence of the factual heterogeneity of the cases: each municipality, each slate, each candidacy presents specific circumstances that hinder closed typification. But the openness is also a consequence of an institutional choice, given that the Court opted to consolidate an open-textured type in precedential format rather than to await legislative mediation that would typify the elements of fraud. The choice was pragmatic and, in terms of effectiveness, successful; however, in terms of strict legality, problematic.

Article 926 of the Code of Civil Procedure determines that the courts shall standardise their jurisprudence and keep it stable, complete and coherent. The coexistence of Precedent No. 73 with Resolution No. 23,735/2024 (one as interpretative consolidation, the other as

procedural regulation) produced a regulatory model coherent in its internal structure, but problematic in its external foundations.

The coherence between the precedential statement and the regulatory resolution does not resolve the prior question, considering that neither of the two instruments can, in isolation or jointly, supply the function that falls to the law in the formal sense, namely, to define the elements of the electoral wrongdoing and its sanctioning consequences.

The integrity of the jurisprudence, in the sense of Article 926, presupposes, first, normative integrity between the regulatory act and the legal basis, and it is precisely this primary integrity that is strained when the regulation exceeds the legal basis. Article 926, therefore, does not cure, but aggravates the primary antinomy, for it requires the stability of a jurisprudence that is founded on a dogmatically fragile instrument.

The first antinomy, in synthesis, is normative in a double sense, having on one side a formal limit, consisting of the excess of regulatory competence, in the use of the instruction for material purposes that exceed the executory function; on the other, a material limit, consisting of the insufficiency of typicity arising from the consolidation of an open-textured type and the dispensation of a constitutive element. This fragility is projected onto the two following antinomies, which are, to a large extent, its consequence.

4 SECOND ANTINOMY: THE CANCELLATION OF THE DRAP AS AN UNCODIFIED SANCTIONING MODALITY

4.1 THE DRAP: LEGAL NATURE AND FUNCTION IN THE REGISTRATION SYSTEM

The Statement of Party Acts Compliance (DRAP) is a procedural document that portrays, before the Electoral Justice, the regularity of the internal process of choosing candidacies by the party or federation. It is not a simple informative document: it is a complex legal act that materialises compliance with the statutory and legal rules on conventions, internal party decisions and composition of the slate, including compliance with the minimum percentage of candidacies of each gender (Article 10, § 3, of Law No. 9,504/1997). Submitted by the party or federation, its approval is a prior condition for the individual registration of candidacies (RRC), in the form of Article 11 of the same Law.

Understanding its nature is decisive for the second antinomy, given that it is an act whose legal ownership belongs to the party, and not to the candidate. The candidate is an indirect addressee, in a tiered relationship: first the party and formal conditions of the slate as a whole (DRAP) are approved and only afterwards the individual conditions of each candidate (RRC). It follows that the cancellation of the DRAP is, materially, a sanction directed at the party, although its immediate effects reach all the candidates of the slate, including

those whose RRC had been approved without any blemish. The DRAP functions as a systemic prerequisite of the collective registration and its cancellation removes the prerequisite, bringing about the collapse of the entire structure.

4.2 AIJE AND AIME: CONSTITUTIONAL AND LEGAL HYPOTHESES OF ADMISSIBILITY

The two electoral actions used as vehicles of the repression of gender quota fraud are the Electoral Judicial Investigation Action (AIJE) and the Action for the Annulment of Elective Mandate (AIME). It is necessary to examine, in some detail, the legal regime of each, so that the magnitude of the jurisprudential innovation may be understood.

The AIJE finds its legal basis in Article 22 of Complementary Law No. 64/1990, and has as its object, classically, three cores: (a) the abuse of economic power in the electoral process; (b) the abuse of political power or of authority to the detriment of electoral equality; and (c) the improper use of social communication media. The typical consequence of a successful AIJE claim, provided for in Article 22, item XIV, of Complementary Law No. 64/1990, is the cancellation of the registration or of the diploma of the beneficiary of the abuse and the declaration of ineligibility of those responsible for a period of eight years.

The AIME, in turn, has constitutional seating in Article 14, §§ 10 and 11, of the Federal Constitution, and has as its object, classically, three distinct cores: (a) the abuse of economic power — a core partially overlapping with that of the AIJE, with distinct consequences; (b) electoral corruption; and (c) fraud in the voting process.

Its typical consequence is the cancellation of the elective mandate, within a peremptory period of fifteen days counted from the certification. Traditionally, the fraud of the constitutional AIME was understood as fraud in the voting (manipulation of ballot boxes, falsification of ballots, illicit capture of suffrage). The extension of this fraud to reach fraud in the composition of the slate, that is, in the pre-electoral phase, was a progressive interpretative operation, today consolidated in the jurisprudence, but which, in the light of the constitutional text, is not trivial.

It should be noted that neither Article 22 of Complementary Law No. 64/1990 nor Article 14, § 10, of the Federal Constitution mention gender quota fraud, nor describe, as an object of either of the two actions, fraud in the composition of the slate, a category distinct from fraud in the voting and chronologically prior to the day of the poll. The construction that extends the admissibility of these actions to quota fraud is, therefore, interpretative, consolidated in successive judgments from 2015–2016 under the simple hermeneutic premise that all electoral fraud constitutes, in the final analysis, a species of abuse of power,

and the purpose of the AIJE would be the generic ascertainment of abuse, without limitation to the literal core of Article 22.

This premise, although defensible, expands, and does not merely apply, the legal type. To apply is to submit the facts to the pre-existing normative hypothesis. To expand is to construct, by interpretative means, a hypothesis that the legal text does not contemplate. The difference, in sanctioning law, is essential.

4.3 THE JURISPRUDENTIAL CONSTRUCTION OF THE CANCELLATION OF THE DRAP FOR QUOTA FRAUD

The cancellation of the DRAP as a consequence of gender quota fraud is not found in any provision of Law No. 9,504/1997, of Complementary Law No. 64/1990 or of the Electoral Code. It is, in its dogmatic origin and in its institutional development, a jurisprudential creation.

The Superior Electoral Court, in finding that the exhaustion of the fraud was located, materially, in the composition of the slate, shifted the object of the sanction from the individual (registration of candidacy) to the party act (DRAP).

The move was necessary at the material level, given that to punish only the fictitious candidate would be insufficient, for it would preserve the party scheme. To punish only the party without reaching the slate would be ineffective, for it would maintain the votes of the scheme. To reach only the leaders would leave the fraudulent act without immediate electoral repercussion. The jurisprudential engineering found, in the cancellation of the DRAP, the point of balance that allowed the production of a substantive electoral effect. But it is, at the formal level, an innovation upon the sanctioning system, and this innovation lacks legislative mediation.

The effects of the cancellation are multiple and grave, for the votes of all the candidates of the proportional slate are annulled, including those not involved in the scheme; the electoral and party quotients are recalculated, affecting the picture of the elected in other party associations of the constituency; and all those responsible are declared ineligible for eight years (Complementary Law No. 64/1990, Article 1, as amended by Complementary Law No. 135/2010). The combination of these effects may, in extreme hypotheses, reconfigure the political representation of an entire constituency.

4.4 LEGAL RESERVATION OF ELECTORAL SANCTIONS AND THE PRINCIPLE OF TYPICITY

The jurisprudential innovation finds a serious dogmatic obstacle in the principle of legal reservation of electoral sanctions. This principle, although not expressly enunciated by the

Federal Constitution in a formula analogous to that of Article 5, item XXXIX (which fixes the reservation of strict law for criminal matters), arises, according to the best doctrine, from the convergence of three constitutional sources: (a) from the nature of political rights as fundamental rights, in accordance with Article 14 et seq. of the Constitution; (b) from the requirement of typicity that governs all sanctioning law, in consonance with the substantive due process of Article 5, item LIV; and (c) from the express reservation of complementary law for the hypotheses of ineligibility, fixed in Article 14, § 9, of the Constitution. The combination of these three sources produces a requirement of strict legality, with material typicity, throughout the field of electoral sanctions.

Electoral sanctions (cancellation of registration, of diploma, of mandate, declaration of ineligibility) affect the core of political rights and must find their foundation in formal law (complementary law in the hypothesis of ineligibility, ordinary law in the case of cancellation of registration or diploma). The cancellation of the DRAP, to the extent that it produces equivalent material effects (collective annulment of candidacies, annulment of votes, recalculation of quotients) without express legal foundation, navigates in problematic terrain.

It is not denied that the constitutional electoral system admits interpretative constructions that expand the reach of the typical actions. It is denied, however, that this expansion can create an autonomous sanctioning modality, with its own effects that exceed the effects provided for the success of the original actions. The difference between broadly interpreting an existing sanction and creating a new sanction is precisely the difference between the lawful and the unlawful from the point of view of typicity.

When a classic AIJE (Article 22 of Complementary Law No. 64/1990) is upheld for abuse of economic power, the effects are exhaustively those provided for in law: cancellation of the registration or of the diploma of the beneficiary and ineligibility of the responsible person for eight years. When the AIJE is upheld for quota fraud, there are added the cancellation of the DRAP, the annulment of all votes of the slate (including those of the non-fraudsters) and the recalculation of the quotients with effects on third parties (none of these effects provided for in Article 22), in addition to ineligibility extended to subjects whose direct participation in the fraud is, at times, indirect.

The two sets are not equivalent, the second being broader, graver and more systemically disruptive. This expansion does not arise from an express legal provision, but from successive jurisprudential construction.

4.5 THE SYSTEMIC EFFECTS: BEYOND THE INFRINGING PARTY

The cancellation of the DRAP reaches agents who did not even participate in the fraud, and this extension is systemic, considering that candidates of the same slate who were unaware of the scheme and campaigned regularly lose their registration and votes without anything being able to be imputed to them. Likewise, parties of the same constituency, never called to the adversarial procedure, have their result altered by the recalculation of the quotients. Voters acting in good faith have their votes annulled by another's act and, furthermore, the very configuration of the proportional representation of the constituency may be substantially altered.

These effects are neither pathological nor do they arise from an error of application, but are inherent in the architecture chosen by the jurisprudence. There is no viable technical solution, in the current configuration, that preserves the useful effect of the sanction and simultaneously isolates the fraudulent agent, considering that if the fraudulent votes were not annulled, the scheme would be discouraged, but not undone. Hence the magnitude of the choice, necessary from the point of view of the useful effect, devastating from the point of view of the extension of the consequences upon third parties.

In the face of such a picture, the absence of a formal law that typifies the hypothesis and provides for the effects is particularly problematic. Today, questions of extreme material gravity are discussed without adequate legislative mediation; after all, does or does not the rule of Article 175, § 4, of the Electoral Code apply (utilisation of votes for the party) to cases of cancellation of the DRAP for quota fraud, with a jurisprudential tendency towards inapplicability, but divergent solutions among the Regional Electoral Courts? Does ineligibility reach the instrumentalised candidate, whom the more recent jurisprudence, in dialogue with Law No. 14,192/2021, tends to exclude, without an express legal rule? Does the recalculation produce retroactive effects on previous elections when the final judgment is delayed? All these questions, of extremely high material effects, are resolved today on a case-by-case basis, without a prior rule, without legal certainty and without rigorous isonomy between analogous situations.

The second antinomy, in synthesis, is the institutionalisation of an atypical sanctioning modality, necessary from the material point of view, atypical from the formal point of view, and generating systemic effects upon third parties who are not parties and who lack specific legislative regulation.

5 THIRD ANTINOMY: THE PASSIVE ILLEGITIMACY OF THE PARTY AND THE CANCELLATION OF THE DRAP

5.1 THE JURISPRUDENCE OF THE TSE ON PASSIVE STANDING IN AIJE

The third antinomy is, perhaps, the most paradoxical of the three. The consolidated jurisprudence of the Superior Electoral Court has established, in successive judgments, the understanding that the political party does not have standing to figure as a defendant in the AIJE. The foundation is doctrinally solid, considering that the AIJE, by its original procedural structure, aimed at the ascertainment of individual conduct that configures abuse of power or improper use of communication media, is directed against the person of the beneficiary of the abuse and against the agents who practised it.

The party, a legal person of private law with a special public function (Article 17 of the Federal Constitution), may act as plaintiff, complainant or opponent, but not as defendant in the procedural legal relationship of the classic AIJE, for the wrongdoing investigated there is, in its typical structure, a wrongdoing of individual conduct, and not an institutional wrongdoing.

The practical consequence is significant, given that in AIJEs for quota fraud, the defendant side is composed of the party leaders, the candidates of the slate in collusion and, in some hypotheses, the candidate identified as fictitious (whom the more recent tendency tends to exclude, under recognition of her condition as a victim).

The party, however, does not figure as a defendant, notwithstanding that it may be summoned, appear as an assistant or be informed of the acts, but does not formally integrate the contentious procedural relationship, with the range of guarantees that the position of defendant confers, such as full adversarial procedure, broad defence, autonomous production of evidence and own appeals.

5.2 THE DRAP AS A PARTY ACT: LEGAL OWNERSHIP

Here arises the logical contradiction that gives its name to the third antinomy. If the upheld AIJE produces, as its main effect, the cancellation of the DRAP, and if the DRAP is, as exposed, indisputably a party act, then the gravest sanction of the action reaches directly a subject that is not a party to the proceedings, that is, the one who could not fully defend himself is punished, and the act whose authorship materially belongs to the one who was kept outside the procedural relationship is cancelled.

The anomaly is not a mere operational deviation, but a structural consequence of the overlap between two regimes: the procedural one of the AIJE (which excludes the party) and the material one of the sanction (which punishes the party).

The objection could be set aside if it were maintained that the DRAP, although subscribed by the party, has the material ownership of the slate (the set of candidates). But the system of registration obstructs this reading, considering that the DRAP is submitted by the party as an act arising from the party convention, its regularity depends on internal party acts, and its irregularity compromises the entire proportional slate, and not only the individual registration of some candidate.

The system thus recognises the party nature of the act. If the act is party in its origin and the effects of the sanction reach it in its totality, the party is, at least materially, the central addressee of the sanction, even if the procedural form excludes it.

5.3 THE INCONGRUITY: PUNISHING THE ONE WHO CANNOT BE A PARTY

The incongruity is of a logical nature before being legal. In any minimally consistent sanctioning system, the sanction is directed at the one who is a party, and a party is the one who was summoned to integrate the procedural relationship with full possibility of defence. When the system admits that the sanction reaches a subject distinct from the procedural party, one is faced with an exception that needs to be, at a minimum, expressly provided for in law and surrounded by supplementary guarantees, notably the recognition, in some form, of the adversarial procedure of the material addressee of the sanction.

Contemporary procedural doctrine (Marinoni, Didier) has dedicated growing attention to the so-called substantial adversarial procedure, which goes beyond the mere formal hearing and requires effective influence over the formation of judicial conviction. In the light of this parameter, the position of the party in proceedings for quota fraud is particularly fragile.

In the case of quota fraud, however, neither one thing nor the other is verified. The hypothesis of cancellation of the DRAP to the detriment of a non-party party is not provided for in law, and the adversarial procedure of the party is, as a rule, oblique, exercised through the leaders who compose the defendant side, but without the party, as an autonomous legal person, formally integrating the procedural relationship.

The consequence is that an arrangement is constructed in which the party is, simultaneously, the holder of the cancelled act and a non-party to the proceedings. This functional duplicity, substantial ownership without procedural ownership, generates two relevant collateral effects. The first is the emptying of the adversarial procedure regarding the regularity of the DRAP, given that as the party is not a party, the defence of the party act depends on the interest and the capacity of the leaders to make it, without there being an institutional guarantee of the autonomous defence of the legal person. The second is the transformation of the party into an external addressee of the judicial decision, that is, a subject

who suffers the material effects without having been able to influence, formally and with full guarantees, its content.

5.4 ATTEMPTS AT RECONCILIATION AND THEIR INSUFFICIENCIES

Doctrine and jurisprudence have attempted to reconcile the contradiction by three avenues. The first maintains that the presence of the party leaders on the defendant side supplies, pragmatically, the adversarial procedure of the party, for it is they who deliberate for the party association and answer for it in court. The objection is evident, given that leaders may have interests divergent from those of the legal person they represent, for, in concrete hypotheses, they may minimise their individual liability at the cost of admitting institutional fraud, or transfer the liability to the party in order to isolate themselves. The coincidence between the defence of the leader and the defence of the party is not necessarily true, and the guarantee of one does not substitute that of the other.

The second avenue maintains that the cancellation of the DRAP, by reaching all the candidates of the slate, would guarantee the adversarial procedure through them, an argument that, in reality, further weakens the position of the legal person of the party. If the adversarial procedure of the party depends on the candidates considered individually, the institutional defence of the party association comes to depend on the interest and the capacity of these candidates to exercise a defence that, materially, is that of the party association. Moreover, the candidates may have no interest in defending the party act in its totality, possibly even preferring to demonstrate their personal dissociation from the fraudulent scheme, to the detriment of the defence of the party. The construction attributes to the third party the function of defending the holder, without the holder being able to exercise it in its own name.

The third avenue, finally, maintains that the inclusion of the order to cancel the DRAP in the requests of the initial pleading of the AIJE would, in itself, be sufficient to configure the adversarial procedure, it being enough for the plaintiff to formulate the request for the system to absorb the sanction as an admissible consequence of success.

This avenue is the most fragile of the three, given that it confuses the request with passive standing and ignores a basic premise of contemporary civil procedure, according to which the request is only effective against the one who is a party to the procedural relationship. The plaintiff may request whatever he wishes; the legal effectiveness of the request to the detriment of a given subject depends on the prior integration of that subject into the procedural relationship. To plead against the one who is not a party is to plead against the procedural void, with material effects that overflow the formal structure of the proceedings.

5.5 THE EMPTIED ADVERSARIAL PROCEDURE AND DUE PROCESS OF LAW

The synthesis of the three dogmatic antinomies is only completed in this third one, where the cancellation of the DRAP, today, is a sanction directed at a subject who is not a party to the proceedings. The fact that the party, materially, exercises its defence through its leaders does not resolve the formal legal question, only circumvents it.

The adversarial procedure, in substantive due process of law (Article 5, items LIV and LV, of the Constitution), is a structuring guarantee of the sanctioning system, and its emptying, even if partial and operationally compensated, compromises the formal legitimacy of the decision. It is not a matter, it is important to stress, of questioning the material justice of the decisions, considering that often, perhaps in most cases, the success of the AIJE for quota fraud is correct at the level of the facts. What is questioned is whether the procedural form adopted satisfies, at the level of institutional architecture, the constitutional requirements that govern any sanctioning system.

The interconnection of the three antinomies becomes, at this point, evident: the regulatory excess opens space for fraud to be typified by instruction, without legislative mediation and with the dispensation of an essential dogmatic element; the atypical sanction uses this administrative type as a vector for the cancellation of the DRAP, not provided for in law, with systemic effects on third parties who are not parties; and the passive illegitimacy reveals that this sanction is directed at a subject who cannot even be a party to the action that applies it.

The three, articulated, compose a system coherent in its practical application, but inconsistent in its formal structure, an inconsistency that, in the long run, tends to compromise the sustainability of the combat against fraud itself and that can only be fully overcome by legislative intervention.

6 FINAL CONSIDERATIONS

The three antinomies examined in this article: the excess of regulatory competence of the Superior Electoral Court, the jurisprudential creation of an uncoded sanctioning modality and the internal contradiction regarding the passive standing of the party, are not contingent pathologies of the current regime of repression of gender quota fraud. They are, rather, structural consequences of a prolonged legislative deficit, which the jurisprudence has supplied, at the material level, at the cost of formal tensions that today accumulate and which, articulated, compose a significant dogmatic challenge to the electoral sanctioning law system.

The jurisprudential construction of the regime, developed in José de Freitas/PI (REspe No. 1-49/PI, 2015), elaborated in Valença do Piauí (REspe No. 193-92/PI, 2019), refined in

Jacobina/BA, consolidated in Precedent No. 73 (2024), regulated by Resolution No. 23,735/2024, met a concrete and urgent need: to preserve the effectiveness of one of the most significant affirmative actions of Brazilian electoral law, against the systematic emptying that party engineering promoted from 2009.

To this legislative deficit is added an effect of a procedural order that merits registration: the prejudice to the jurisdiction itself. As the regime of repression of quota fraud was constructed on a regulatory and jurisprudential basis, and not on federal law in the strict sense, the party that intends to submit the controversy to the Superior Electoral Court by means of an electoral special appeal encounters a structural difficulty of admissibility.

The electoral special appeal presupposes, under the terms of Article 121, § 4, of the Federal Constitution and Article 276 of the Electoral Code, the contrariety to an express provision of the Constitution or of law; but, when the core of the wrongdoing and of its sanctioning consequences rests on a resolution of the Court itself and on a precedential statement, and not on a legal text, identifying the violated federal rule becomes an arduous task, when not impossible.

The consequence is paradoxical, given that the fragility of the legal basis, which is the core of the three antinomies examined, is also projected onto access to the special instance, restricting the appeal avenue through which the very interpretation of the regime could be standardised and controlled. The absence of a federal law to which a violation can be imputed, in the strict sense, thus operates in a double disadvantage, in that it weakens the material legitimacy of the sanction and narrows the channel of its jurisdictional review.

The material legitimacy of this trajectory is not questioned; on the contrary, its institutional indispensability is recognised. What is maintained, in this article, is that the normalisation of the regime, its consolidation in stable and legally consistent dogmatic forms, requires legislative intervention which the current state of affairs cannot continue to substitute indefinitely. The jurisprudential construction fulfilled its function of emergency response, and what is now demanded is the legislative consolidation of this arrangement, with the overcoming of the dogmatic tensions that the regulatory form cannot resolve.

Three normative propositions arise from the diagnosis presented in this article. The first is the express legal typification of gender quota fraud. The insertion, in Law No. 9,504/1997 — preferably in a specific provision, articulated with Article 10, § 3 — of a rule that describes the elements of the wrongdoing (including the eventual dispensation of the subjective element, if that is the option of the democratically legitimated legislator) would overcome the controversy regarding the limits of Article 105 and stabilise the regime at the level of strict legality. The legal rule could, moreover, confer on Precedent No. 73 a

retrospective legislative foundation, remedying the original fragility of the jurisprudential construction.

The second is the express legal provision of the cancellation of the DRAP as an autonomous sanctioning modality, with specific discipline regarding its effects. It would fall to the legislator to define: (a) the material hypotheses of admissibility; (b) the regime of annulment of the votes, that is, whether they reach the party or only the candidates considered individually; (c) the regime of recalculation of the quotients, with provision of the effects on third parties; (d) the regime of the consequent ineligibility, with individualisation of the subjects reached; and (e) the applicable procedural regime, including the procedural rite and the available appeals. The legal consolidation of these points would confer on the institute the typicity today absent, with a substantial gain in legal certainty.

The third is the express provision of the passive standing of the party in the actions that may culminate in the cancellation of the DRAP, with explicitation of the mechanisms of adversarial procedure, defence and individualisation of responsibilities. The inclusion of the party as a legitimate party, and not merely as an oblique addressee of the effects, would resolve the antinomy between material ownership and procedural exclusion, and would offer the legal person of the party the guarantees that its condition as addressee of the sanction requires. In dialogue with Law No. 14,192/2021, it would also fall to the legislator to regulate the position of the instrumentalised candidate, legally consecrating the jurisprudential tendency that recognises her as a victim of the wrongdoing.

Until this intervention exists, the combat against gender quota fraud will continue to depend, in its formal structure, on jurisprudential construction whose limits are continually strained with each new paradigmatic decision, with an accumulation of dogmatic fragilities that tend, over time, to compromise the very authority of the institutional response.

The function of this article does not consist in delegitimising the current regime, but in signalling its dogmatic tensions, a task that falls to the doctrine before falling to the jurisprudence or the legislator. It is in this spirit, that of one who recognises the relevance of the material programme of gender equality in politics and, precisely for this reason, is concerned with the dogmatic stability of its instrument of protection, that these reflections are offered.

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COST OF TIMBER FOREST MANAGEMENT IN THE AMAZON: A CASE STUDY IN THE STATE OF ACRE

CUSTO DO MANEJO FLORESTAL MADEIREIRO NA AMAZÔNIA: UM ESTUDO DE CASO NO ESTADO DO ACRE

COSTO DEL MANEJO FORESTAL MADERERO EN LA AMAZONIA: UN ESTUDIO DE CASO EN EL ESTADO DE ACRE

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ABSTRACT

This work addressed sustainable forest management (SFM) in the state of Acre and its purpose was to identify the cost of timber production coming from managed areas in that state. To this end, data were collected at four local logging firms. The results allowed us to conclude that: a) at a distance of 50 kilometres the timber arrived at the sawmill yard at a value of R\$346.64 per m³ for hardwood and R\$279.64 per m³ for white wood; b) forest exploitation presented itself as the most expensive stage of management; c) the cost of forest management tends to become cheaper on more distant lands, yet this does not compensate for the cost of transporting the timber to the sawmill yard; and d) there is nothing to reduce in the cost of management, therefore a better way to conduct the industrialisation processes must be identified, adding value to the product.

Keywords: Forest Management. Cost of Timber Production. Economic Forest-Sawmill Distance.

RESUMO

Este trabalho abordou o manejo florestal sustentável (MFS) no estado do Acre e o seu objetivo foi identificar o custo da produção madeireira oriunda de áreas manejadas nesse estado. Para tal, foram coletados dados em quatro firmas madeireiras locais. Os resultados permitiram concluir que: a) em uma distância de 50 quilômetros a madeira chegou ao pátio da serraria no valor de R\$346,64 m³ para madeira dura e R\$279,64 m³ para madeira branca; b) a exploração florestal apresentou-se como a etapa mais cara do manejo; c) o custo do manejo florestal tende a ficar mais barato em terras mais distantes, porém não compensa pelo valor do transporte da madeira até o pátio da serraria e d) não há o que reduzir no custo do manejo, sendo assim, deve-se identificar uma melhor forma de conduzir os processos de industrialização agregando valor ao produto.

Palavras-chave: Manejo Florestal. Custo da Produção Madeireira. Raio Econômico.

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RESUMEN

Este trabajo abordó el manejo forestal sostenible (MFS) en el estado de Acre y su objetivo fue identificar el costo de la producción maderera proveniente de áreas manejadas en ese estado. Para ello, se recolectaron datos en cuatro empresas madereras locales. Los resultados permitieron concluir que: a) a una distancia de 50 kilómetros la madera llegó al patio del aserradero por un valor de R\$346,64 m³ para madera dura y R\$279,64 m³ para madera blanca; b) la explotación forestal se presentó como la etapa más cara del manejo; c) el costo del manejo forestal tiende a abarataarse en tierras más distantes, pero no compensa por el valor del transporte de la madera hasta el patio del aserradero y d) no hay qué reducir en el costo del manejo, por lo tanto, se debe identificar una mejor forma de conducir los procesos de industrialización agregando valor al producto.

Palabras clave: Manejo Forestal. Costo de la Producción Maderera. Radio Económico.

1 INTRODUCTION

The Brazilian Amazon holds one third of the world's tropical forests, with an estimated volume of 60 billion cubic metres of roundwood (BARROS; VERÍSSIMO, 2002) and performs incalculable ecological, sociocultural and economic functions, since it sustains the economy of entire regions (BARRETO *et al*, 2005).

It is appropriate to mention that, seeking the continuous use of forest resources, sustainable forest management was developed, the concept of SFM. This type of use of forest resources refers to the form of management of a forest in order to meet the needs of current and future generations, without compromising the ecological capacity and the renewal potential of this resource (WANG, 2004). The main obstacles to forest management are listed as the lack of basic and applied scientific research that guarantees the regeneration of the species extracted by selective logging and, above all, the high cost of its implementation (GARRIDO FILHA, 2002).

Silva *et al.* (2007) emphasise that high transport cost may render forest exploitation unfeasible in areas located far from consumption centres, since the timber industries consider forest exploitation to be the most expensive stage of management. Thus, it is valid to consider that timber is an input (or product) of low specific value, that is, its value in relation to its weight is low, which makes its transport cost high. In addition, variables such as the price of timber, costs of forest production, of the project, interest rate, lack of working capital, among others, affect the profitability of the forestry activity and, consequently, influence the quantification of the maximum feasible transport distance.

From the above, it is timely to carry out studies on the costs of forest production, including the items sustainable forest management, exploitation and industrial industrialisation. And it can be argued that the results of such research, having the state of Acre as a scenario, have the potential to support the development of public policies that promote the rational use of forests in this region. Such an assertion is based on the fact that currently this state has 95% of its exploited timber originating from management plans. Thus, this study had as its main objective to identify the cost of the timber activity, in managed areas, in the state of Acre.

2 MATERIAL AND METHODS

2.1 MATERIAL

Data collection took place through the application of a form in face-to-face interviews with members of the Acre timber sector, numbering four (two in the capital of Rio Branco, one in the municipality of Sena Madureira and one in the municipality of Feijó).

As proposed by Silva and Santos (2011), the aforementioned form focused on the themes: (1) identification of the firm; (2) characterisation of the Sustainable Forest Management Plan (PMFS) and its Annual Operating Plan (POA); (3) costs of planning and the opening of roads and branch trails (R\$/m³); (4) price paid for the exploited timber species (R\$/m³); (5) volume of exploited timber (m³) and (6) cost of the extraction and forest transport activities (R\$/m³).

2.2 METHODS

2.2.1 Cost of standing timber production

The cost of timber production was identified and quantified using the following mathematical model, developed by Silva and Santos (2011):

$$C_{mm} = S_{mp} + C_{mf} \quad (1)$$

Where C_{mm} = Cost of sustainable production of standing timber (R\$/m³); S_{mp} = Average price of standing timber in a deforestation area, and practised in Rio Branco (R\$/m³) and C_{mf} = Cost of SFM production (R\$/m³).

To quantify the cost of SFM production, as suggested by Klemperer (1996) and Wagner (2012), a cash flow was used which, applied to the concepts of financial mathematics, focused on a cutting-cycle period of 25 years with an interest rate of 6% per annum. In this calculation the following expression, presented by Silva and Santos (2011), was employed:

$$C_{sfm} = \frac{\sum_{t=0}^n \frac{C_t}{(1+i)^t}}{\frac{V_m}{(1+i)^{te}}} \quad (2)$$

Where C_{mf} = Cost of SFM (R\$/m³); C_t = Cost of SFM operations, in year t (R\$/ha); V_m = Volume of exploited timber (m³/ha); i = Interest rate, expressed as a decimal (0.0*i*); te = year in which exploitation occurred.

3 RESULTS AND DISCUSSION

The average values obtained on the characterisation of the PMFS and POA indicated that the commercial productivity of the forests exploited by these firms was 12 m³/ha. In turn, the price charged by the forest engineering firm to prepare and approve the PMFS was R\$80.00/ha.

The average prices found in Rio Branco for standing timber were R\$37.00/m³ for the white wood species and R\$55.00/m³ for the noble and hard species. As the hardwood and noble species had equal prices, they were considered to make up a single group, here called hardwood.

Table 1 lists the cost items of the harvesting/forest exploitation activities per m³ and costs with different freight charges (50 and 100 kilometres).

Table 1

Costs of the harvesting activity in sustainable forest management, state of Acre, 2014

Stages	Price (R\$/m ³)
Forest felling	8.67
Forest skidding	26.67
Road construction	13.50
First loading	7.80
Forwarding	10.00
Second loading	3.00
Miscellaneous costs	5.00
Opening of branch trail	45.00
Forest transport (50 km)	45.00
Forest transport (100 km)	70.00

Source: prepared by the authors.

Table 2

Costs of timber originating from a managed area, placed in the sawmill yard, state of Acre, year 2014

Item	Hardwood (R\$/m ³)	White wood (R\$/m ³)
SFM + standing tree (R\$/m ³)	182.00	115.00
Forest exploitation (R\$/m ³)	119.64	119.64
Transport (50 km*) (R\$/m ³)	45.00	45.00
Total (R\$/m ³)	346.64	279.64
SFM + standing tree (R\$/m ³)	135.00	89.00
Forest exploitation (R\$/m ³)	119.64	119.64
Transport (100 km*) (R\$/m ³)	70.00	70.00
Total (R\$/m ³)	324.64	278.64

Source: prepared by the authors.

Note: (*) distance, forest-yard of the timber firm.

The cost of forest management has an inverse relationship to distance (transport of the timber). This happens because the cost of management considers the value of the cubic

metre of the standing tree, and this tends to become cheaper as the land becomes farther from the commercial centre. Considering an economic radius of 50 kilometres, it could be stated that the cubic metre of hardwood arrived at the sawmill yard at a value of R\$346.64/m³ and R\$279.64/m³ for white wood. For 100 kilometres this value decreased by about 7% for hardwood and 0.40% for white wood.

The values of the standing tree and of the log placed in the yard found in this study were considered high when compared to the values found by the study of the Instituto do Homem e Meio Ambiente da Amazônia – IMAZON in Belém do Pará in the year 2010, considered the cheapest cubic metre of the Amazon because it was exploited over great distances (688 kilometres) and transported by means of barges (fluvial transport).

4 CONCLUSIONS

From the results generated in this economic evaluation of corporate forest management, it was possible to infer the following points:

- a) The cost of exploiting roundwood is the most expensive stage of forest management;
- b) The cost of forest management tends to become cheaper on more distant lands, yet this does not compensate due to the fact that the value of the freight of the timber to the timber yard becomes more expensive;
- c) The cost of SFM is already at the limit, there is nothing to reduce. Therefore, a better way to conduct the industrialisation processes must be identified and value added to the product.

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ARTIFICIAL INTELLIGENCE FOR ENVIRONMENTAL MONITORING: AUTOMATED IDENTIFICATION AND COUNTING OF BENTHIC MACROFAUNA USING CONVOLUTIONAL NEURAL NETWORKS

INTELIGÊNCIA ARTIFICIAL PARA O MONITORAMENTO AMBIENTAL: IDENTIFICAÇÃO E CONTAGEM AUTOMATIZADAS DA MACROFAUNA BENTÔNICA POR REDES NEURAIS CONVOLUCIONAIS

INTEGENCIA ARTIFICIAL PARA EL MONITOREO AMBIENTAL: IDENTIFICACIÓN Y CONTEO AUTOMATIZADOS DE LA MACROFAUNA BENTÓNICA UTILIZANDO REDES NEURONALES CONVOLUCIONALES



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ABSTRACT

Benthic macrofauna; including mollusks, crustaceans, and polychaetes; plays a crucial role in regulating biogeochemical cycles, stabilizing sediments, and maintaining aquatic ecosystem resilience. Owing to their high sensitivity to environmental perturbations, these organisms are extensively used as bioindicators in ecological monitoring and impact assessments. Nevertheless, their traditional identification and enumeration rely on manual, labor-intensive procedures that demand taxonomic expertise and are susceptible to subjectivity and human error. To overcome these limitations, this study presents a robust and fully automated system based on Convolutional Neural Networks (CNNs) for the detection and quantification of benthic macrofauna from digital microscopy images. The proposed workflow encompasses standardized image acquisition, taxonomic annotation, advanced pre-processing, data augmentation, and supervised deep learning model training implemented in Python. Evaluation of the system revealed a mean F1-score of 0.93, mAP50 of 0.939, and inference times below 10 milliseconds per image, while maintaining stable validation precision, recall, and mAP values throughout training. Moreover, precision and recall metrics remained consistently high across diverse taxa, and the mean Average Precision (mAP50 and mAP50–95) improved steadily during training. These outcomes confirm the system's high generalization capacity and computational efficiency, enabling rapid, reliable, and reproducible ecological data generation. Beyond technical performance, the solution supports scalable biodiversity assessments, strategic environmental decision-making, and the optimization of conservation efforts, particularly in the face of climate change. This integration of artificial intelligence with benthic ecology represents a significant advancement in digital environmental monitoring, offering a cost-effective, time-efficient, and scientifically rigorous alternative to conventional analytical methods.

Keywords: Environmental Bioindicators. Convolutional Neural Networks (CNNs). Decision Making. Climate Change.

RESUMO

A macrofauna bentônica, incluindo moluscos, crustáceos e poliquetas, desempenha um papel crucial na regulação dos ciclos biogeoquímicos, na estabilização dos sedimentos e na

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manutenção da resiliência dos ecossistemas aquáticos. Devido à sua elevada sensibilidade às perturbações ambientais, esses organismos são amplamente utilizados como bioindicadores no monitoramento ecológico e em avaliações de impacto. Contudo, sua identificação e contagem tradicionais dependem de procedimentos manuais e laboriosos que exigem expertise taxonômica e são suscetíveis à subjetividade e ao erro humano. Para superar essas limitações, este estudo apresenta um sistema robusto e totalmente automatizado baseado em Redes Neurais Convolucionais (CNNs) para a detecção e quantificação da macrofauna bentônica a partir de imagens de microscopia digital. O fluxo de trabalho proposto abrange aquisição padronizada de imagens, anotação taxonômica, pré-processamento avançado, aumento de dados e treinamento supervisionado de modelos de aprendizado profundo implementado em Python. A avaliação do sistema revelou um F1-score médio de 0,93, mAP50 de 0,939 e tempos de inferência inferiores a 10 milissegundos por imagem, mantendo valores estáveis de precisão, revocação e mAP de validação ao longo do treinamento. Além disso, as métricas de precisão e revocação permaneceram consistentemente elevadas entre diversos táxons, e a precisão média (mAP50 e mAP50–95) melhorou de forma constante durante o treinamento. Esses resultados confirmam a alta capacidade de generalização e a eficiência computacional do sistema, possibilitando a geração rápida, confiável e reprodutível de dados ecológicos. Além do desempenho técnico, a solução apoia avaliações escaláveis de biodiversidade, a tomada de decisão ambiental estratégica e a otimização dos esforços de conservação, particularmente diante das mudanças climáticas. Essa integração da inteligência artificial com a ecologia bentônica representa um avanço significativo no monitoramento ambiental digital, oferecendo uma alternativa econômica, eficiente em tempo e cientificamente rigorosa aos métodos analíticos convencionais.

Palavras-chave: Bioindicadores Ambientais. Redes Neurais Convolucionais (CNNs). Tomada de Decisão. Mudanças Climáticas.

RESUMEN

La macrofauna bentónica, incluyendo moluscos, crustáceos y poliquetos, desempeña un papel crucial en la regulación de los ciclos biogeoquímicos, la estabilización de los sedimentos y el mantenimiento de la resiliencia de los ecosistemas acuáticos. Debido a su alta sensibilidad a las perturbaciones ambientales, estos organismos se utilizan ampliamente como bioindicadores en el monitoreo ecológico y en las evaluaciones de impacto. No obstante, su identificación y enumeración tradicionales dependen de procedimientos manuales y laboriosos que exigen experiencia taxonómica y son susceptibles a la subjetividad y al error humano. Para superar estas limitaciones, este estudio presenta un sistema robusto y totalmente automatizado basado en Redes Neuronales Convolucionales (CNNs) para la detección y cuantificación de la macrofauna bentónica a partir de imágenes de microscopía digital. El flujo de trabajo propuesto abarca la adquisición estandarizada de imágenes, la anotación taxonómica, el preprocesamiento avanzado, el aumento de datos y el entrenamiento supervisado de modelos de aprendizaje profundo implementado en Python. La evaluación del sistema reveló un F1-score medio de 0,93, mAP50 de 0,939 y tiempos de inferencia inferiores a 10 milisegundos por imagen, manteniendo valores estables de precisión, exhaustividad y mAP de validación a lo largo del entrenamiento. Además, las métricas de precisión y exhaustividad se mantuvieron consistentemente altas entre diversos taxones, y la precisión media (mAP50 y mAP50–95) mejoró de forma constante durante el entrenamiento. Estos resultados confirman la alta capacidad de generalización y la eficiencia computacional del sistema, permitiendo la generación rápida, confiable y reproducible de datos ecológicos. Más allá del desempeño técnico, la solución apoya evaluaciones escalables de biodiversidad, la toma de decisiones ambientales estratégicas y la optimización de los esfuerzos de conservación, particularmente frente al cambio climático. Esta integración de la inteligencia artificial con la ecología bentónica representa un avance

significativo en el monitoreo ambiental digital, ofreciendo una alternativa rentable, eficiente en tiempo y científicamente rigurosa a los métodos analíticos convencionales.

Palabras clave: Bioindicadores Ambientales. Redes Neuronales Convolucionales (CNNs). Toma de Decisiones. Cambio Climático.

1 INTRODUCTION

Aquatic ecosystems depend critically on benthic macrofauna, a diverse assemblage of invertebrates including mollusks, crustaceans, polychaetes, and echinoderms, to sustain fundamental ecological processes. Occupying the sediment-water interface, these organisms drive biogeochemical cycles such as organic matter decomposition, nutrient regeneration, and sediment oxygenation, while simultaneously serving as sensitive bioindicators of environmental quality (Avelino *et al.*, 2023; Kuhlmann, 2022; Hale *et al.*, 2024). Their intimate association with the substrate and low dispersal capacity make them particularly responsive to variations in sediment composition, oxygen availability, temperature, pH, and contaminant loadings, rendering them indispensable tools for ecological monitoring in estuarine, coastal, and lagoon ecosystems (Sousa *et al.*, 2023; Moura *et al.*, 2023).

Maintaining the ecological integrity of lagoon systems requires continuous monitoring of benthic communities, as these organisms mediate essential biogeochemical functions including nutrient cycling, pollutant filtration, and sediment stabilization. Their spatial distribution and abundance patterns reliably reflect environmental impacts associated with pollution gradients, granulometric shifts, and anthropogenic disturbances such as bottom trawling (Li *et al.*, 2022; Bradshaw *et al.*, 2024). Standard benthic sampling protocols involve the selection of georeferenced stations across environmental gradients, with multiple replicates per point to ensure statistical reliability. Sample recovery is typically performed using corers, dredges, or nets, followed by sieving, fixation in ethanol, and taxonomic sorting under stereomicroscopy (Kuhlmann, 2022; Pardo *et al.*, 2023).

Laboratory processing of benthic samples relies on stereomicroscopic examination combined with dichotomous identification keys to classify organisms into functional groups. Ecological quality is subsequently assessed through biological indices that integrate species diversity, abundance, and dominance, enabling spatial and temporal comparisons across monitoring programs (Sun *et al.*, 2021; Han *et al.*, 2021). Although scientifically rigorous, this workflow is time-consuming, operator-dependent, and demands highly specialized taxonomic expertise, constraints that severely limit the scale and frequency of monitoring campaigns and hinder timely responses to environmental degradation (Ghimire *et al.*, 2021; Neves and Valentin, 2011).

Computer vision based on Convolutional Neural Networks (CNNs) has emerged as a transformative solution to automate image-based biodiversity assessments. By learning hierarchical spatial representations directly from labeled images, CNNs can distinguish morphologically similar taxa with high accuracy, even under variable lighting and background conditions (Villon *et al.*, 2018; Xu *et al.*, 2020; Zhu *et al.*, 2021). Their capacity to process

thousands of images per hour, with inference times below 10 milliseconds, makes them particularly well-suited for high-throughput ecological screening. Deep learning frameworks such as PyTorch and TensorFlow have further democratized access to these architectures, enabling their deployment in research and regulatory monitoring contexts (LeCun *et al.*, 2015; Krizhevsky *et al.*, 2012).

Despite this growing adoption across aquatic sciences, targeted applications of CNNs to benthic macrofauna in lagoon environments remain scarce. Existing models have largely focused on planktonic organisms, coral reefs, and fish assemblages (Ferreira *et al.*, 2022; Mizuno *et al.*, 2024), leaving a critical methodological gap for sediment-dwelling invertebrates. The morphological complexity of benthic taxa, characterized by appendage segmentation, shell curvature, body transparency, and sediment adhesion, demands specialized training datasets, tailored augmentation strategies, and robust image processing pipelines to achieve reliable classification under real ecological conditions.

Addressing this gap is particularly urgent given the accelerating pace of global environmental change. Lagoon and estuarine systems are among the ecosystems most vulnerable to sea-level rise, ocean acidification, eutrophication, and hypoxic events (IPCC, 2023; Duarte *et al.*, 2013). Benthic macrofauna, by virtue of their sedentary lifestyle and narrow physiological tolerance, function as early-warning sentinels of these stressors. Automating their identification and quantification substantially expands the temporal and spatial resolution of biodiversity data, enabling the detection of ecological imbalances and long-term community shifts that would otherwise go undetected (Borja *et al.*, 2010; McLeod *et al.*, 2011).

Beyond ecological monitoring, this research carries strategic implications for climate adaptation governance and blue carbon policy. Continuous, high-frequency benthic data support environmental licensing processes, certification of blue carbon projects, and the construction of long-term biodiversity indicators aligned with the Sustainable Development Goals (SDGs) and the Convention on Biological Diversity (CBD). The preservation of macrofaunal integrity underpins ecosystem services, sediment stabilization, nutrient cycling, and carbon sequestration, that are central to coastal resilience frameworks (Barbier *et al.*, 2011; Howard *et al.*, 2017; UNEP, 2021).

This study presents the development, training, and validation of a CNN-based automated system for the identification and enumeration of benthic macrofauna from digital microscopy images. The proposed pipeline integrates standardized image acquisition, manual taxonomic annotation, data augmentation, and supervised model training in Python. Model performance is evaluated through accuracy, F1-score, recall, and mean Average

Precision (mAP), ensuring practical applicability for large-scale ecological monitoring. The novelty of this work lies in adapting CNN architectures to the specific morphological and imaging challenges of benthic macrofauna, with direct implications for accelerating biodiversity assessments and strengthening evidence-based environmental decision-making.

Although recent advances in artificial intelligence have substantially expanded the use of deep learning techniques in ecological monitoring, applications focused on benthic macrofauna remain limited, particularly in lagoon ecosystems. Most existing studies have concentrated on fish assemblages, coral reefs, plankton communities, or broad marine biodiversity assessments, leaving a significant methodological gap regarding sediment-associated invertebrates. Furthermore, few studies have explored the integration of automated benthic monitoring with environmental governance and strategic decision-making frameworks (Zang *et al.*, 2019). Consequently, there is a growing need for intelligent and scalable solutions capable of accelerating laboratory screening procedures while simultaneously generating reliable ecological indicators to support environmental management and climate adaptation policies.

2 MATERIALS AND METHODS

2.1 STUDY AREA AND SAMPLING PROCEDURES

The study was conducted in the Maricá Lagoon, a hypersaline coastal lagoon situated in the state of Rio de Janeiro, southeastern Brazil. Embedded within a broader complex of Atlantic-domain coastal lagoons, this system is characterized by pronounced environmental heterogeneity, including gradients of salinity, tidal exchange, sediment composition, and organic matter concentration driven by both natural dynamics and anthropogenic pressures such as urban runoff and shoreline modification. These features make it an ecologically sensitive and scientifically valuable site for investigating the spatial distribution and community structure of benthic macrofauna.

Sampling stations were selected based on stratified environmental gradients encompassing proximity to urban discharge points, sediment type, and vegetation cover, with logistical constraints of accessibility and safety also considered. This stratification aimed to ensure spatial representation across distinct ecological zones and to capture the full range of benthic community variability within the lagoon system.

Field campaigns were conducted during both the dry and rainy seasons to account for temporal variability associated with freshwater inflows and precipitation. Surface sediments were collected using a cylindrical corer (10 cm diameter, 15 cm penetration depth), targeting

the uppermost sediment horizon where macroinvertebrate abundance is highest. At each of the 30 georeferenced stations, three replicate cores were obtained ($n = 90$ total), and the material was immediately sieved through a 500 μm mesh in the field to remove excess sediment and retain macrofauna.

Retained organisms were preserved in 70% ethanol and transported to the laboratory, where specimens were sorted under a stereomicroscope and prepared for imaging and taxonomic classification. The focal taxa; polychaetes, amphipods, and gastropods; were selected for their ecological relevance as bioindicators of sediment quality and their representation across the sampled environmental gradients.

2.2 IMAGE ACQUISITION AND ANNOTATION

High-resolution digital images were obtained from each biological sample using a digital microscope equipped with adjustable LED lighting and a uniform background substrate. Image capture followed a standardized protocol to ensure consistent illumination, magnification, and contrast across all samples, thereby minimizing sources of technical variability in the training dataset. Each specimen was individually positioned and photographed under controlled conditions.

All images were manually annotated using bounding boxes to delimit and taxonomically classify each visible organism, generating a structured labeled dataset suitable for supervised object detection training. The species included in the training set were *Heliobia* spp., *Streblospio* sp., and *Cassidinidea fluminensis*. To reflect differences in acquisition conditions, three imaging subsets were defined: *Heliobia*N (specimens photographed under normal magnification without microscopy), *Heliobia*M (specimens imaged with one microscope configuration), and *Heliobia*M1 (specimens imaged with an alternative microscope setup). The remaining taxa were annotated exclusively from one microscopy modality.

2.3 MODEL ARCHITECTURE AND TRAINING STRATEGY

The annotated image dataset was partitioned into training (80%) and validation (20%) subsets using stratified sampling to preserve class proportions across splits. To enhance model generalizability and mitigate overfitting, data augmentation was applied during training, including horizontal and vertical flipping, brightness and contrast perturbations, and zoom transformations. The full pipeline was implemented using a supervised deep learning framework in Python.

The network architecture followed a convolutional design comprising successive feature extraction stages. Convolutional layers captured low- and mid-level spatial features; edges, textures, and morphological patterns; while max-pooling layers progressively reduced spatial dimensionality. Batch normalization was applied after each convolutional block to stabilize gradient flow and accelerate convergence. Fully connected layers at the output stage integrated the learned feature representations to generate species-level classifications via a softmax activation function.

Model training was guided by a composite loss function combining three terms: a bounding box localization loss (L_{box}), a cross-entropy classification loss (L_{cls}), and a Distribution Focal Loss (L_{dfl}) that assigns greater weight to difficult instances. The total loss is expressed as:

$$L_{\text{total}} = L_{\text{box}} + L_{\text{cls}} + L_{\text{dfl}} \quad (1)$$

The localization loss penalizes spatial misalignment between predicted and ground-truth bounding boxes:

$$L_{\text{box}} = \sum_{i=1}^N \delta_i \cdot \text{IoU}_{\text{loss}}(\hat{b}_i, b_i) \quad (2)$$

where N is the total number of predicted objects; $\delta_i \in \{0, 1\}$ indicates whether prediction i constitutes a valid match; $\hat{b}_i$ and b_i are the predicted and ground-truth bounding boxes, respectively; and IoU_{loss} can be instantiated as GloU , DloU , or CloU to penalize poor localization alignment.

The classification loss minimizes the cross-entropy between predicted probabilities and true taxonomic labels:

$$L_{\text{cls}} = -\sum_{i=1}^N \sum_{c=1}^C y_{i,c} \cdot \log(\hat{p}_{i,c}) \quad (3)$$

where C is the number of classes; $y_{i,c} \in \{0, 1\}$ is the ground-truth label for instance i and class c ; and $\hat{p}_{i,c}$ is the predicted softmax probability for that class.

The Distribution Focal Loss refines bounding box regression by concentrating learning on harder examples:

$$L_{\text{dfl}} = -\sum_{i=1}^N \sum_{j=1}^M w_{i,j} \cdot \log(p_{i,j}) \quad (4)$$

where M is the number of discrete regression bins; $w_{i,j}$ is the target-distribution weight for bin j of instance i ; and $p_{i,j}$ is the predicted probability for that bin.

Training was performed using stochastic gradient descent with adaptive learning rate scheduling and early stopping criteria. The final model checkpoint was selected based on the highest $mAP@50$ achieved on the validation set. All computations were executed on a workstation equipped with an NVIDIA RTX 3060 GPU.

2.4 EVALUATION METRICS AND PERFORMANCE ANALYSIS

Model performance was assessed using a multi-metric framework combining standard classification and object detection indicators, computed at both per-class and aggregate levels to characterize overall and class-specific behavior.

Precision quantifies the proportion of detections that are truly positive among all detections made by the model:

$$\text{Precision} = \frac{TP}{TP + FP} \quad (5)$$

Recall measures the proportion of actual positive instances that the model successfully detected:

$$\text{Recall} = \frac{TP}{TP + FN} \quad (6)$$

The F1-Score provides the harmonic mean of precision and recall, offering a balanced evaluation that accounts for both false positives and false negatives:

$$F_1 = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}} \quad (7)$$

The mean Average Precision at $IoU \geq 0.50$ ($mAP@50$) summarizes detection performance across all classes at a standard localization threshold:

$$mAP@50 = \frac{1}{M} \sum_{i=1}^M \int_0^1 p_i(r) dr \quad (8)$$

where M is the number of classes and $p_i(r)$ denotes the precision–recall function for class i , with the integral computing the area under that curve at $IoU = 0.50$.

To provide a stricter and more comprehensive localization assessment, the mAP@50:95 metric averages detection performance across ten IoU thresholds from 0.50 to 0.95 in 0.05 increments:

$$\text{mAP@50:95} = \frac{1}{T} \sum_{t=1}^T \left[\frac{1}{M} \sum_{i=1}^M \int_0^1 p_{i,t}(r) dr \right] \quad (9)$$

where $T = 10$ is the number of thresholds and $p_{i,t}(r)$ is the precision–recall curve for class i at threshold t . Inference time per image was additionally recorded to evaluate real-time applicability in laboratory workflows.

2.5 POST-PROCESSING METRICS AND CONFIDENCE EVALUATION

Detection confidence scores were derived from the classification probability output of the final prediction layer, yielding a probability estimate over the K taxonomic classes. A prediction was considered valid only if its confidence score exceeded an empirically defined threshold (typically 0.25–0.50), thereby balancing sensitivity to low-abundance taxa against the suppression of false positives.

Overall classification accuracy was computed as:

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}} \quad (10)$$

where TP, TN, FP, and FN denote true positives, true negatives, false positives, and false negatives, respectively. This metric captures the proportion of all predictions — both presences and absences — that were correctly classified.

The confidence score C for a given input x is formally defined as the maximum softmax probability across all classes:

$$C = \max_{k \in \{1, \dots, K\}} P(y = k \mid x) \quad (11)$$

where $P(y = k \mid x)$ is the model's estimated probability that input x belongs to class k , and the max operator identifies the most likely taxonomic assignment. Confidence intervals for precision and accuracy estimates were determined through bootstrapping on validation subsets to ensure statistical robustness of reported performance values.

2.6 JUSTIFICATION OF METRIC SELECTION

The adoption of a multi-metric evaluation framework is warranted by the ecological complexity inherent to benthic monitoring. In conservation contexts, false negatives, undetected species, may result in the overlooking of rare or functionally critical taxa, whereas false positives risk inflating biodiversity assessments and misguiding management decisions. Precision and recall directly quantify these error types and are therefore indispensable for ecologically valid performance reporting.

The mAP metrics extend evaluation to the spatial domain, assessing the accuracy with which the model localizes each specimen within the image. This is especially important for small, partially occluded, or morphologically convergent organisms that are common in complex sediment samples. The combined use of classification and localization metrics ensures that the system meets the dual requirements of taxonomic accuracy and spatial precision demanded by environmental monitoring applications.

Confidence thresholds and inference time metrics further provide the operational parameters needed for scaling the system to automated laboratory pipelines and mobile field stations, where processing speed and prediction reliability are equally critical considerations. Together, these indicators constitute a comprehensive and ecologically grounded evaluation standard aligned with both scientific best practices and regulatory monitoring requirements.

3 RESULTS

This section provides a comprehensive evaluation of the CNN model developed for the automated identification and enumeration of benthic macrofauna. The assessment encompasses quantitative performance metrics; precision, recall, F1-score, and mean Average Precision; alongside an examination of training dynamics, confusion matrices, and detection examples. Taken together, these elements characterize the model's predictive capacity, operational reliability, and readiness for integration into ecological monitoring workflows.

3.1 CNN MODEL PERFORMANCE

The training dataset comprised 219 digital microscopy images of varying resolution, encompassing both single-species and multi-species compositions. Of these, 133 images were allocated to training and 86 to validation. The model was trained in a Python 3.9.13 environment with CUDA GPU acceleration (Torch 2.5.1) on an NVIDIA RTX 3060. The final architecture consisted of 168 layers and 11,128,293 parameters, operating at 28.5 GFLOPs,

a moderately complex configuration well-suited to the scale of the dataset. Figure 1 summarizes the key output parameters recorded at the conclusion of training.

Figure 1

Final training output parameters

Epoch	GPU_mem	box_loss	cls_loss	dfl_loss	Instances	Size			
200/200	3.89G	0.3846	0.2305	0.8446	41	640: 100%	9/9	[00:02<00:00, 4.14it/s]	
Class	Class	Images	Instances	Box(P	R	mAP50	mAP50-95)	100%	3/3 [00:00<00:00, 4.20it/s]
all		86	706	0.946	0.899	0.934	0.676		

Source: author.

Validation was performed over 86 images containing 706 annotated instances distributed across five taxonomic classes. Among individual classes, HeliobiaN achieved a precision of 0.977, recall of 0.960, mAP50 of 0.939, and mAP50–95 of 0.522. HeliobiaM recorded precision of 0.968, recall of 0.786, mAP50 of 0.847, and mAP50–95 of 0.737. HeliobiaM1 attained precision of 0.931, recall of 0.973, mAP50 of 0.948, and mAP50–95 of 0.742. Streblospio_spM yielded precision of 0.937 and recall of 0.817, with mAP50 of 0.916 and mAP50–95 of 0.585. The highest overall performance was recorded for Cassid_Flum, which achieved a precision of 0.961, perfect recall of 1.000, mAP50 of 0.995, and mAP50–95 of 0.847. Although Cassid_Flum achieved the highest performance metrics, these results should be interpreted with caution due to the limited number of validation instances available for this class.

Across all classes, the model attained a mean mAP50 of 0.939 and an overall F1-score of 0.93, confirming strong classification capacity. The mAP50–95 of 0.687 indicates that while localization at standard thresholds is robust, performance at stricter IoU criteria leaves room for improvement, a limitation primarily attributable to the limited size of the current dataset, for which expansion is recommended. Inference was computationally efficient: pre-processing required 0.3 ms, inference 6.9 ms, and post-processing 0.8 ms per image, demonstrating suitability for real-time laboratory screening. Figure 2 presents the confusion matrices for the trained model.

Figure 2

Confusion matrix: (a) absolute counts, (b) normalized by class

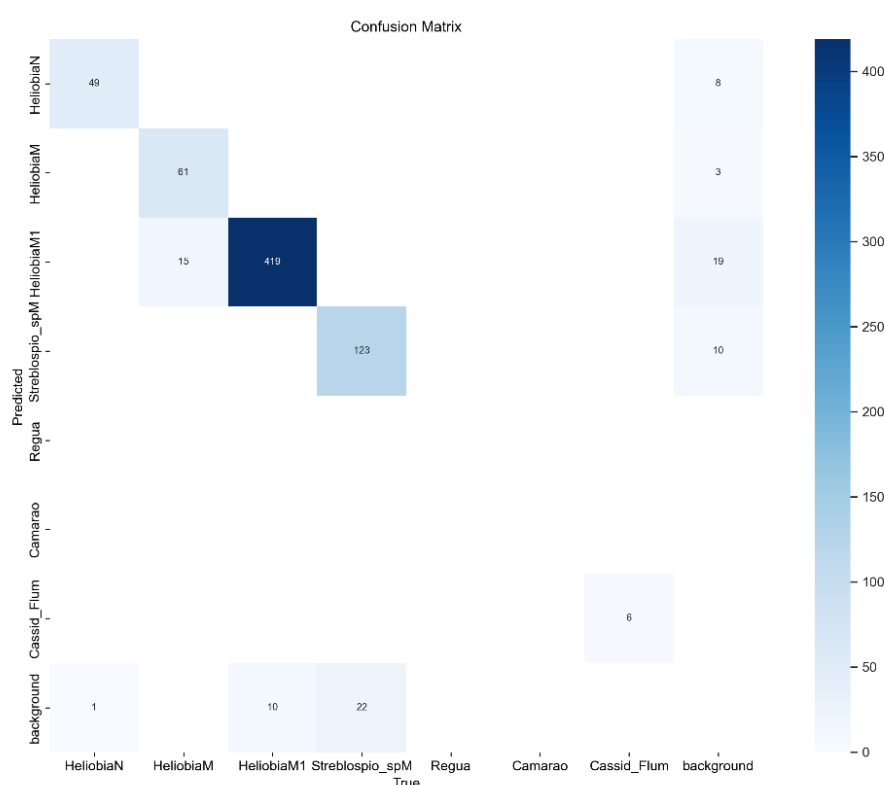
Class	Images	Instances	Box(P	R	mAP50	mAP50-95)
all	86	706	0.955	0.907	0.939	0.687
HeliobiaN	5	50	0.977	0.96	0.99	0.522
HeliobiaM	10	76	0.968	0.786	0.847	0.737
HeliobiaM1	38	429	0.931	0.973	0.948	0.742
Streblospio_spM	38	145	0.937	0.817	0.916	0.585
Cassid_Flum	3	6	0.961	1	0.995	0.847

Source: author.

The absolute confusion matrix confirms concentrated correct predictions along the main diagonal: 49 instances for HeliobiaN, 61 for HeliobiaM, 419 for HeliobiaM1, 123 for Streblospio_spM, and 6 for Cassid_Flum. The normalized matrix reveals per-class accuracy rates of 0.98 for HeliobiaN, 0.80 for HeliobiaM, 0.98 for HeliobiaM1, 0.85 for Streblospio_spM, and 1.00 for Cassid_Flum. The confusion between HeliobiaM and HeliobiaM1 suggests that differences introduced by microscope configuration may have affected class separability. Moreover, the presence of false negatives classified as background, particularly for Streblospio_spM, indicates that small or partially overlapping organisms remain challenging for the model. These findings reinforce the importance of image standardization and dataset expansion to improve detection robustness. The comparatively lower recall of HeliobiaM (0.80) likely reflects imaging inconsistencies between the two microscope configurations used for that class, reinforcing the need for standardized acquisition protocols. Figure 3 presents the key performance curves.

Figure 3

Performance metrics: F1-Confidence (a), Precision–Confidence (b), Precision–Recall (c), and Recall–Confidence (d)



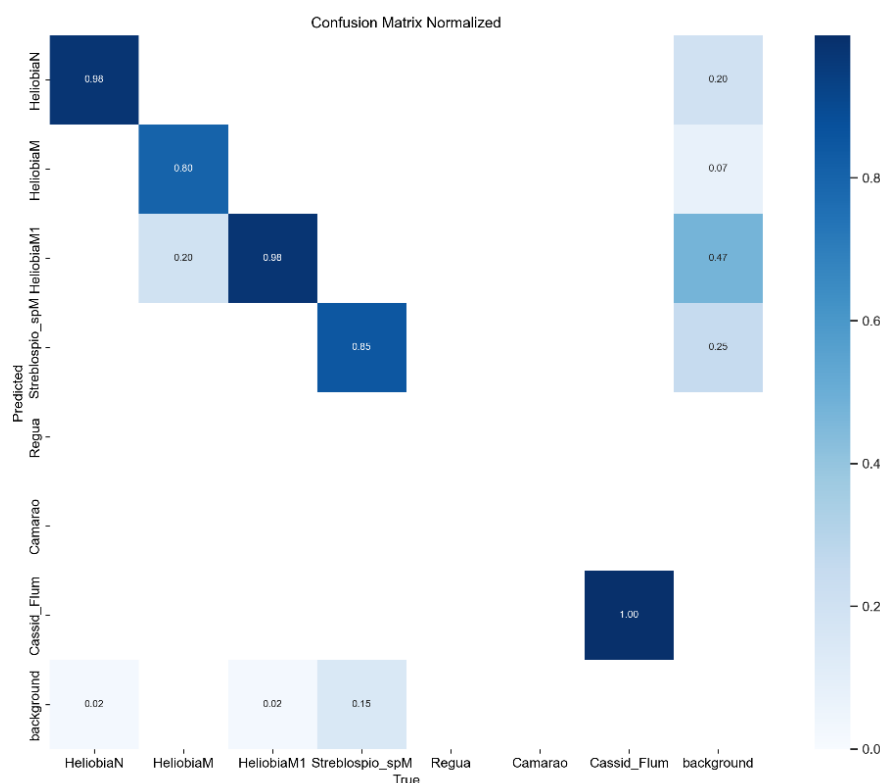
Source: author.

The F1-Confidence curve stabilizes at 0.93 at a confidence threshold of 0.625, reflecting a well-balanced trade-off between precision and recall across the operating range.

The Precision-Confidence curve demonstrates that precision reaches 1.00 at a threshold of 0.98, indicating that highly confident predictions are almost exclusively correct, a desirable property for applications where taxonomic misidentification carries regulatory consequences. The Precision-Recall curve shows that a mean average precision of 0.939 is maintained up to recall levels of 0.5, representing an optimal generalization regime. At higher recall levels, precision decreases for some classes, particularly *Streblospio_spM*, suggesting that conservative thresholding may be preferable in surveys targeting rare taxa. The Recall-Confidence curve confirms that high recall is sustained at low confidence thresholds and degrades progressively as the threshold is raised, a trade-off inherent to all detection systems. Figure 4 presents the full training and validation learning curves.

Figure 4

Training and validation loss, precision, recall, and mAP curves across 200 epochs



Source: author.

The training loss components (box, classification, and DFL) decreased consistently throughout the 200 training epochs, indicating progressive optimization of model parameters. In the validation set, classification loss decreased and stabilized, while box loss remained relatively stable after the initial training stages. The validation DFL loss exhibited a slight increase during later epochs, suggesting that bounding-box refinement may still benefit from a larger and more diverse dataset. Nevertheless, precision, recall, mAP50, and mAP50–95

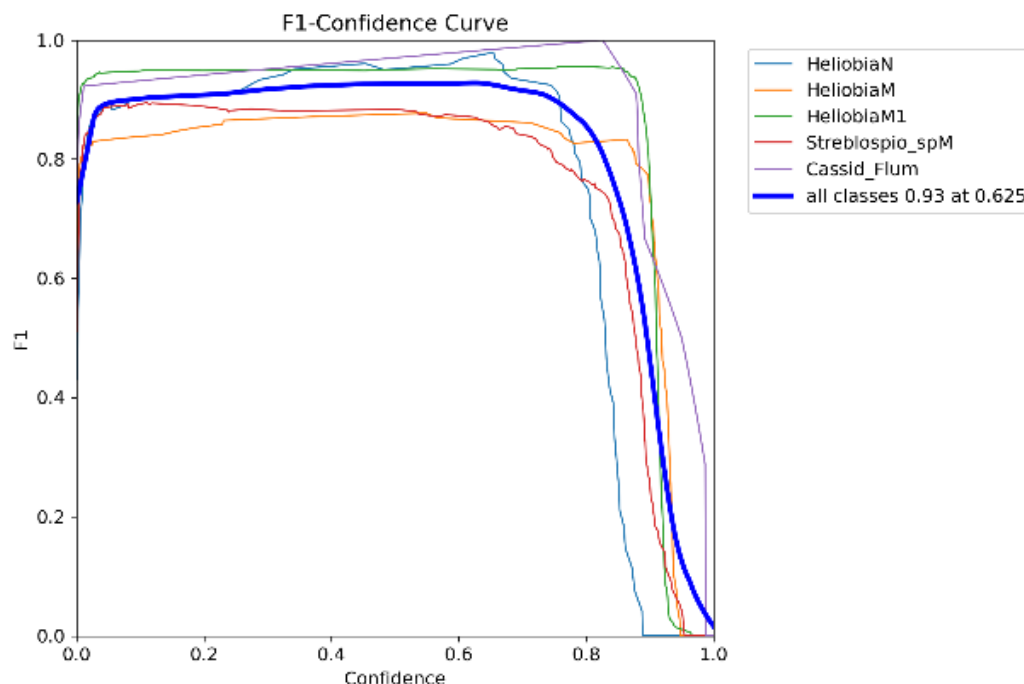
remained stable or improved during training, indicating satisfactory generalization to unseen data. These results are comparable to, and in some cases exceed, those reported in previous ecological monitoring studies employing deep learning techniques. Villon *et al.* (2018) demonstrated the feasibility of applying deep learning techniques to underwater species classification, while Zhu *et al.* (2021) highlighted the challenges associated with maintaining high precision when dealing with morphologically similar taxa., while Zhu *et al.* (2021) highlighted the difficulty of maintaining high precision when dealing with morphologically similar taxa. The F1-score of 0.93 obtained in the present study therefore demonstrates that CNN-based approaches can achieve robust performance even when applied to small benthic invertebrates exhibiting substantial morphological variability.

3.2 AUTOMATED DETECTION AND COUNTING RESULTS

The automated detection system demonstrated strong performance across speed, taxonomic accuracy, and generalization, even given the relatively small and heterogeneous image dataset spanning both microscopy and non-microscopy acquisition conditions. The mean inference time of under 10 ms per image supports real-time integration into laboratory triage workflows, substantially reducing the time burden of manual screening. Figures 5 through 9 illustrate representative detection outputs alongside manual reference counts for each taxonomic class.

Figure 5

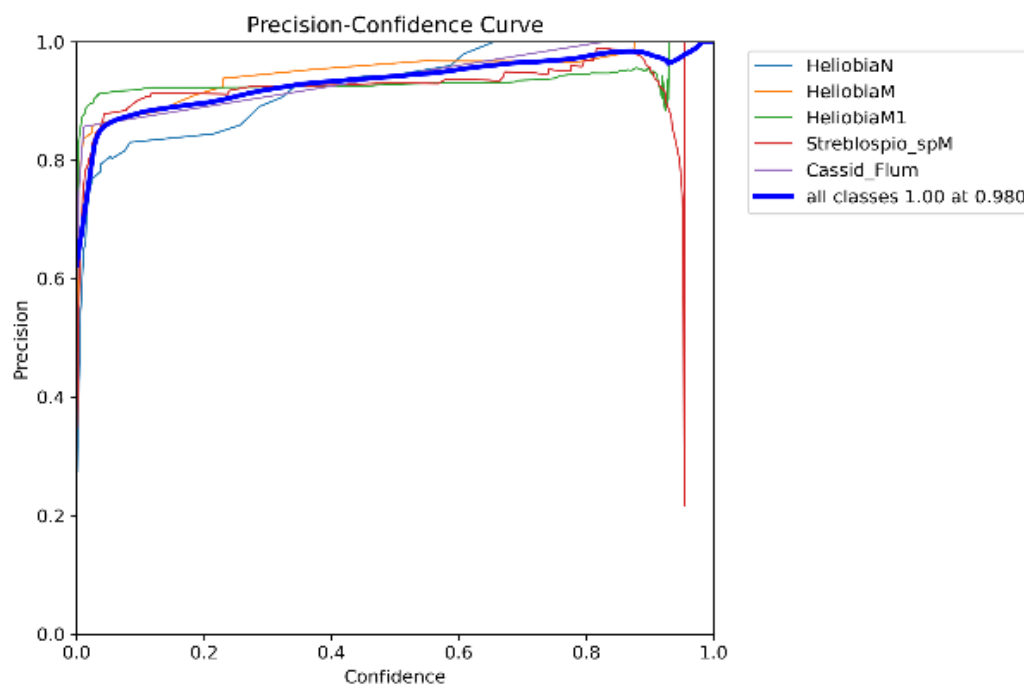
Detection output and confidence statistics: HeliobiaN (standard magnification). 100% correct species identification and counting



Source: author.

Figure 6

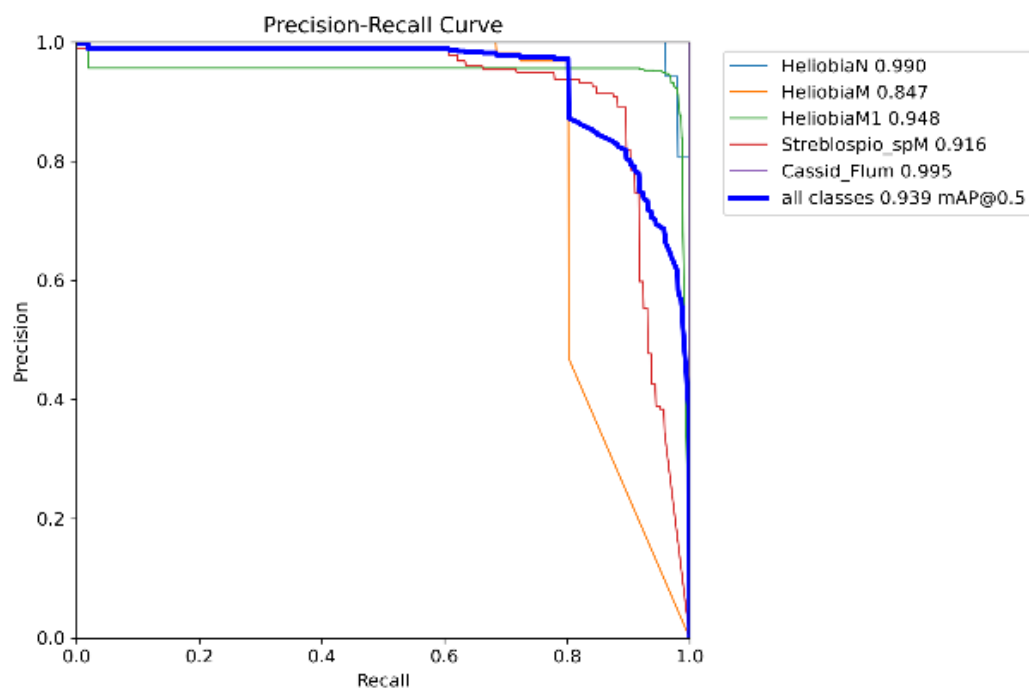
Detection output and confidence statistics: HeliobiaM1 (microscopy, configuration 1). 100% correct species identification and counting



Source: author.

Figure 7

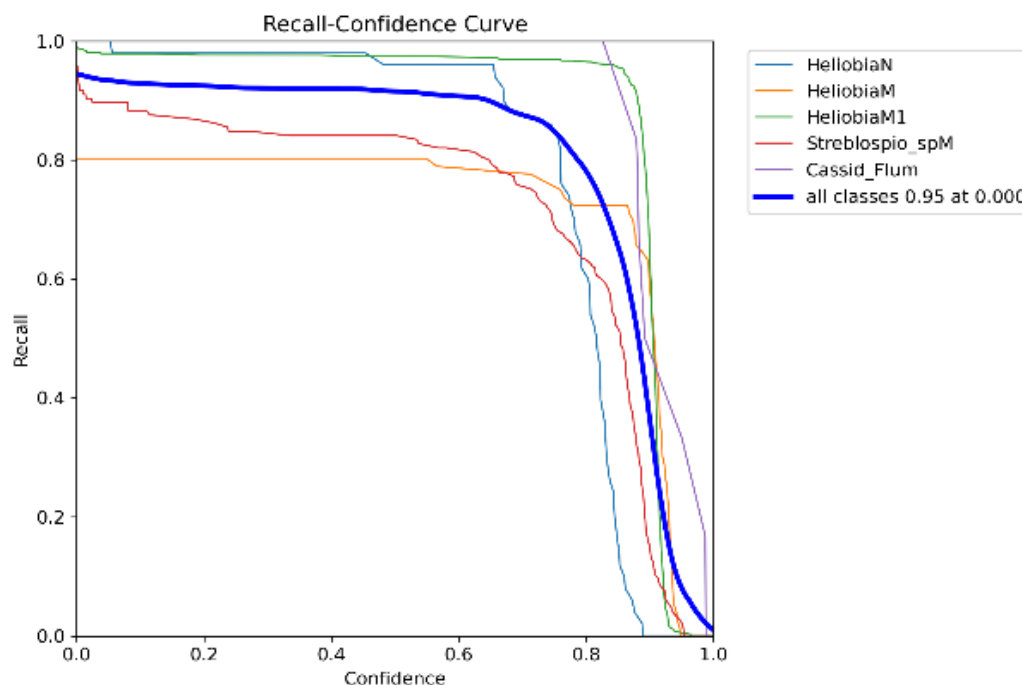
Detection output and confidence statistics: Cassid_Flum (microscopy). 100% correct species identification and counting



Source: author.

Figure 8

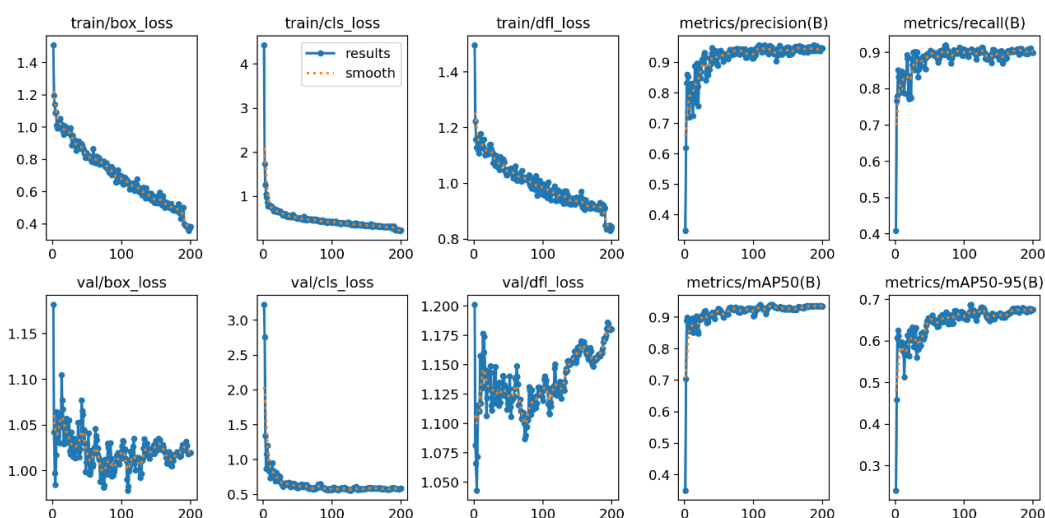
Detection output and confidence statistics: Streblospio_spM (microscopy, mixed sample). 100% accuracy in species identification and approximately 45% accuracy in specimen counting



Source: author.

Figure 9

Detection output and confidence statistics: HeliobiaM1 and Streblospio_spM (microscopy, mixed sample). 100% correct species identification and counting



Source: author.

Automated counts matched manual reference counts within a 5% error margin for correctly classified instances. Deviations were predominantly associated with low-image-

quality samples and overlapping specimens, two conditions that degrade bounding box discrimination and inflate both false positive and false negative rates. These findings underscore the importance of image acquisition standardization and point toward dataset expansion, particularly for underrepresented classes and challenging imaging scenarios, as the primary avenue for further performance improvement.

The system's alignment with Industry 4.0 principles enables its integration into continuous ecological monitoring architectures, supporting automated data pipelines, anomaly detection, and decision support interfaces. This capability represents a substantive shift from reactive, sample-driven monitoring toward proactive, data-continuous surveillance of benthic community dynamics.

3.3 COMPARISON WITH TRADITIONAL LABORATORY SCREENING

Traditional benthic macrofauna screening relies on manual identification and counting performed by trained taxonomists under stereomicroscopes. Although processing times vary according to sample complexity, manual laboratory screening typically requires several minutes to hours per sample, whereas the proposed CNN performs image inference in less than 10 ms, representing a substantial increase in analytical throughput.

Considering that a single laboratory sample may contain dozens to hundreds of individuals requiring manual sorting and identification, the computational efficiency achieved by the proposed model represents a substantial reduction in processing time and human effort. This gain becomes particularly relevant in long-term monitoring programs involving large numbers of samples and repeated surveys.

Beyond speed, automated screening contributes to process standardization by reducing operator-dependent variability, which is a common source of inconsistency in ecological assessments. While expert validation remains essential, particularly for rare or morphologically similar taxa, the proposed approach significantly reduces the workload associated with routine laboratory procedures.

These findings indicate that artificial intelligence can serve as a complementary tool for benthic monitoring programs, increasing analytical throughput while preserving acceptable levels of taxonomic accuracy and reproducibility.

3.4 IMPLICATIONS FOR ENVIRONMENTAL GOVERNANCE

The proposed system extends beyond a purely technological contribution and presents important implications for environmental governance. By enabling faster and more frequent assessments of benthic communities, the approach facilitates the generation of

continuous ecological indicators that can support environmental licensing, biodiversity monitoring programs, and adaptive management strategies.

Because benthic macrofauna are highly sensitive to environmental disturbances, automated monitoring systems can function as early-warning tools for detecting ecological degradation associated with pollution, eutrophication, habitat alteration, and climate-related stressors. The availability of standardized and reproducible biodiversity information strengthens evidence-based decision-making and contributes to more transparent environmental management processes.

Furthermore, the integration of artificial intelligence into environmental monitoring frameworks aligns with current global initiatives related to ecosystem conservation, climate adaptation, blue carbon programs, and sustainability governance. As environmental datasets become increasingly complex and voluminous, intelligent monitoring systems are expected to play a central role in supporting strategic environmental planning and long-term ecosystem resilience.

4 CONCLUSIONS AND FUTURE WORKS

This study demonstrated that Convolutional Neural Networks can be effectively trained to automate the identification and enumeration of benthic macrofauna from digital microscopy images, achieving high classification accuracy, robust generalization, and inference speeds compatible with real-time laboratory deployment. The trained model attained a mean mAP50 of 0.939 and an F1-score of 0.93 across five taxonomic classes, with per-class accuracy reaching 0.98 for *HeliobiaN* and *HeliobiaM1* and 1.00 for *Cassid_Flum*. These results confirm that the proposed pipeline constitutes a scientifically rigorous and operationally practical alternative to conventional manual triage methods.

From a strategic environmental management perspective, the implications of this work extend well beyond laboratory efficiency. Automating benthic macrofauna analysis enables the continuous integration of sensitive ecological indicators into decision-making processes, expanding the planning, control, and risk-response capabilities of both public agencies and private operators. The system provides a high-throughput decision-support tool for environmental licensing, ecological impact assessment, and biodiversity certification, facilitating a transition from reactive to proactive conservation strategies grounded in real-time empirical evidence.

In the context of global climate change, the capacity to generate continuous, georeferenced, and statistically validated time series of benthic community data represents a strategic advance. Benthic macrofauna respond sensitively to temperature anomalies,

dissolved oxygen depletion, and contaminant accumulation, precisely the stressors intensifying under current climate trajectories. Early-warning signals embedded in these time series can inform adaptive management plans, trigger timely interventions, and support the delineation of priority conservation zones, thereby operationalizing the climate resilience frameworks demanded by national and international environmental policy.

The practical scalability of the approach is a further key contribution. Expanding monitoring frequency and spatial coverage without proportional increases in operational cost removes a longstanding barrier to continuous ecological surveillance. The proposed approach has potential applicability within environmental monitoring programs associated with National Adaptation Plans, Payment for Environmental Services initiatives, and blue carbon projects. Despite the promising results, the present study has some limitations. The image dataset used for training and validation was relatively small and restricted to a limited number of taxonomic groups. Additionally, the images were obtained under controlled laboratory conditions, which may differ from other acquisition environments. Future studies should expand the dataset, incorporate additional species, and evaluate the model under different imaging conditions to further improve its robustness and generalization capability.

Future work should prioritize three complementary directions. First, dataset expansion across additional taxa, sampling seasons, and image acquisition conditions will be essential to improve mAP50–95 performance and consolidate generalization across the morphological diversity encountered in real monitoring programs. Second, integration of the model into end-to-end automated triage platforms; combining image acquisition hardware, detection inference, and ecological database management; will unlock the full operational potential of the system. Third, the development of transfer learning strategies to adapt the trained model to new geographic regions and lagoon systems with minimal additional annotation effort will substantially broaden its applicability and accelerate adoption by monitoring agencies worldwide.

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FROM PLANNING TO POST-OCCUPANCY: A REVIEW ON THE PERFORMANCE OF NATURE-BASED SOLUTIONS IN URBAN AREAS

DO PLANEJAMENTO À PÓS-OCUPAÇÃO: UMA REVISÃO SOBRE O DESEMPENHO DE SOLUÇÕES BASEADAS NA NATUREZA EM ÁREAS URBANAS

DE LA PLANIFICACIÓN A LA POSTOCUPACIÓN: UNA REVISIÓN SOBRE EL DESEMPEÑO DE LAS SOLUCIONES BASADAS EN LA NATURALEZA EN ÁREAS URBANAS



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ABSTRACT

Nature-Based Solutions (NBS) have been adopted in urban planning as alternatives to address environmental problems associated with urbanisation and climate change, including heat islands, flooding, and the reduction of green areas. This systematic review examined studies on the implementation, performance, and post-occupancy evaluation of different types of urban green infrastructure. The findings indicate that urban parks and street trees tend to present more stable long-term results due to accessibility and lower maintenance requirements. In contrast, green roofs and vertical greenery systems increase opportunities for vegetation in densely urbanised areas but require continuous irrigation, maintenance, and specialised technical support. The review also identified differences between the benefits expected during planning stages and the results observed after implementation. Factors related to public management, community participation, maintenance, and socioeconomic conditions directly influence the permanence and effectiveness of these strategies in urban environments. In addition to environmental benefits, the reviewed studies discuss social and economic impacts associated with public space use, property valorisation, and socio-spatial inequalities.

Keywords: Nature-Based Solutions. Green Infrastructure. Post-Occupancy Evaluation. Urban Planning. Urban Sustainability.

RESUMO

As Soluções Baseadas na Natureza (SBN) têm sido utilizadas no planejamento urbano como alternativas para enfrentar problemas ambientais associados à urbanização e às mudanças climáticas, como ilhas de calor, enchentes e redução das áreas verdes. Esta revisão

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sistemática analisou estudos sobre implementação, funcionamento e avaliações pós-ocupação de diferentes infraestruturas verdes urbanas. Os resultados indicam que parques urbanos e arborização viária apresentam maior estabilidade ao longo do tempo devido à acessibilidade e menor necessidade de manutenção. Em contrapartida, telhados verdes e jardins verticais ampliam a inserção da vegetação em áreas densamente urbanizadas, mas exigem irrigação, manutenção contínua e suporte técnico especializado. A pesquisa também identificou diferenças entre os benefícios previstos no planejamento e os resultados observados após a implantação das intervenções. Aspectos relacionados à gestão pública, participação comunitária, manutenção e condições socioeconômicas influenciam diretamente a permanência e a efetividade dessas estratégias nas cidades. Além dos benefícios ambientais, os estudos analisados discutem impactos sociais e econômicos relacionados ao uso dos espaços públicos, valorização imobiliária e desigualdades socioespaciais.

Palavras-chave: Soluções Baseadas na Natureza. Infraestrutura Verde. Avaliação Pós-Ocupação. Planejamento Urbano. Sustentabilidade Urbana.

RESUMEN

Las Soluciones Basadas en la Naturaleza (SBN) han sido utilizadas en la planificación urbana como alternativas para enfrentar problemas ambientales asociados con la urbanización y el cambio climático, como islas de calor, inundaciones y reducción de áreas verdes. Esta revisión sistemática analizó estudios sobre implementación, funcionamiento y evaluaciones postocupación de diferentes infraestructuras verdes urbanas. Los resultados indican que los parques urbanos y el arbolado viario presentan mayor estabilidad a lo largo del tiempo debido a la accesibilidad y a la menor necesidad de mantenimiento. Por otro lado, los techos verdes y jardines verticales amplían la inserción de vegetación en áreas densamente urbanizadas, pero requieren riego, mantenimiento continuo y soporte técnico especializado. La investigación también identificó diferencias entre los beneficios previstos en la planificación y los resultados observados después de la implementación de las intervenciones. Aspectos relacionados con la gestión pública, la participación comunitaria, el mantenimiento y las condiciones socioeconómicas influyen directamente en la permanencia y efectividad de estas estrategias en las ciudades. Además de los beneficios ambientales, los estudios analizados discuten impactos sociales y económicos relacionados con el uso de los espacios públicos, la valorización inmobiliaria y las desigualdades socioespaciales.

Palabras clave: Soluciones Basadas en la Naturaleza. Infraestructura Verde. Evaluación Postocupación. Planificación Urbana. Sostenibilidad Urbana.

1 INTRODUCTION

The rapid process of urbanisation and climate change has been overloading environmental systems and urban infrastructure. In response, many cities have been adopting Nature-Based Solutions (NBS), often referred to as “Green Zones”, as part of urban regeneration and resilience strategies (Ahn & Juraev, 2023; Balzan *et al.*, 2022; Ferreira *et al.*, 2020; Fox-Kämper *et al.*, 2023). Green Zones include habitat restoration initiatives, urban vegetation, and a range of green infrastructures: green roofs, urban forests, and wetlands (Berg *et al.*, 2024; Coleman *et al.*, 2023; Metwally & Ibrahim, 2022). These initiatives are commonly associated with improvements in air quality, temperature regulation, water management, and biodiversity, as well as potential benefits for human health (Arnberger *et al.*, 2024; Fouad *et al.*, 2023; Lampinen *et al.*, 2022; Santamouris & Osmond, 2020).

Concurrently, urban expansion and the demands of an increasingly digital and consumerist society continue to reduce natural areas and intensify climatic problems such as heat islands, flooding, and the scarcity of natural resources (Kajosaari *et al.*, 2024; Mens *et al.*, 2021; Zhao *et al.*, 2024). In this context, NBS are promoted as effective responses, and their behaviour varies according to the scale of project implementation and maintenance over time.

Beyond environmental aspects, these interventions are also linked to social and economic effects, including changes in the real estate market, in local urban activities, and in the community use of spaces (Lampinen *et al.*, 2023; Morpurgo *et al.*, 2023). However, the results are not always consistent, and improvements do not always correspond to the expectations created during the planning of the proposals over time.

This systematic review examines the effects of NBS, focusing on the possible discrepancy between expected and actual effectiveness. By systematising studies that include post-occupancy evidence, the aim is to identify limitations, contextual factors, and socioeconomic implications linked to green interventions.

2 MATERIALS AND METHODS

Adopting the literature review method, this research uses a methodology structured in three distinct phases, with the aim of (1) identifying, (2) evaluating, and (3) synthesising research on the impacts of NBS and green zones in urban areas. Two main themes guide these stages: the implementation process of Nature-Based Solutions and post-occupancy evaluations, seeking to understand factors that may influence the implementation and permanence of these strategies in urban planning.

For the development of the systematic review, software and digital platforms aimed at searching, organising, and analysing scientific literature were used. The bibliographic searches were carried out through the Science Direct, Scopus, and Portal de Periódicos CAPES databases. The Zotero software was used for storing, organising, and managing the bibliographic references selected throughout the research. The SciSpace platform was used as support for reading, interpreting, and systematising the scientific articles analysed. ChatGPT (OpenAI) was used only as an auxiliary tool for preliminary textual organisation and clarity review, without participation in the selection of studies, critical interpretation of the data, or formulation of the scientific results.

Following a previously defined protocol, the review sought to ensure greater transparency and comprehensiveness in its stages. The initial phase included the bibliographic search, the selection of studies based on previously established inclusion and exclusion criteria, the critical evaluation of the relevance of the selected works, and the synthesis of the main information identified in the literature. This approach allowed the gathering of different perspectives related to the environmental, social, and economic effects of NBS in urban contexts.

2.1 LITERATURE SEARCH AND SELECTION

The selection of studies considered works related to the urban context and to Nature-Based Solutions, prioritising peer-reviewed articles, research focused on the implementation of green infrastructure, and studies associated with the environmental, social, and economic effects of these interventions. Research related to public perception, community participation, appropriation of green spaces, and post-occupancy evaluation of NBS was also included. Duplicate publications, studies without a direct relationship to the urban context, and works without access to the full content were disregarded during the screening.

The bibliographic searches were carried out in the Science Direct, Scopus, and Portal de Periódicos CAPES databases, using combinations of keywords related to NBS, social impacts, public acceptance, public satisfaction, and appropriation of green spaces. The survey aimed to gather research focused both on environmental effects and on the experiences and perceptions associated with green infrastructure in urban areas.

Table 1

Summary of preliminary searches for the initial evaluation of NBS projects

Database	Date	TITLE/ABS/KEY	Number of Articles
Portal de Periódicos CAPES	10/09/2024	TITLE/ABS/KEY "NBS" AND "social impacts" OR	225

		"public acceptance" OR "public satisfaction" OR "public appropriation".	
Scopus	10/09/2024	TITLE/ABS/KEY "nature-based solutions" AND "social impacts" OR "public acceptance" OR "public satisfaction" OR "public appropriation"	583
Science Direct	10/09/2024	TITLE/ABS/KEY "nature-based solutions" AND "social impacts" OR "public acceptance" OR "public satisfaction" OR "public appropriation"	622
Total			1430

Source: prepared by the authors, 2026.

After the initial bibliographic survey stage, the identified works underwent a new screening, considering their direct relationship with the research objectives. Priority was given to studies associated with the environmental and social impacts of NBS in urban areas, especially those focused on the implementation, use, and permanence of these strategies over time. At the end of this stage, 75 articles were selected for full reading and in-depth analysis, together with texts considered relevant for the theoretical foundation of the research.

In addition to the searches related to the implementation and effects of NBS, specific searches focused on post-occupancy evaluations were also carried out. For this, combinations of terms related to post-occupancy evaluation and Nature-Based Solutions were used, seeking to identify studies that analysed differences between the benefits expected during planning and the results observed after the implementation of the interventions.

Table 2

Summary of preliminary searches for post-occupancy evaluations

Database	Date	TITLE/ABS/KEY	Number of Articles
Portal de Periódicos CAPES	18/12/2024	TITLE/ABS/KEY "post-occupancy evaluation" AND "NBS"	0
Scopus	18/12/2024	TITLE/ABS/KEY on "post-occupancy evaluation" AND "nature-based solutions"	0
Google Scholar	18/12/2024	TITLE/ABS/KEY on "post-occupancy evaluation"	206

		AND “nature-based solutions”	
Science Direct	18/12/2024	TITLE/ABS/KEY on “post-occupancy evaluation” AND “nature-based solutions”	7
Total			213

Source: prepared by the authors, 2026.

The studies related to post-occupancy evaluations also underwent a screening stage, considering mainly research focused on the behaviour of NBS in real conditions of use, including environmental, social, and economic aspects observed after the implementation of the projects. After this process, 22 articles were selected for detailed analysis.

From the integration of these studies, the review sought to understand how factors related to maintenance, management, community participation, and urban context may influence the effectiveness of NBS over time. In addition to the environmental benefits frequently associated with green infrastructure, the analysis also considered aspects linked to public perception, accessibility, property valorisation, and socio-spatial inequalities observed in different urban contexts.

2.2 DATA SYNTHESIS AND ANALYSIS

The extracted data were synthesised and organised through a narrative approach, allowing the interpretation of the main results identified in the reviewed studies. The analyses were structured into thematic axes related to the environmental, social, and economic impacts of NBS in urban contexts. Among the themes analysed are the environmental gains associated with green infrastructure, the social effects related to the perception and use of spaces, the economic effects found in different urban contexts, and the practical challenges linked to the implementation, maintenance, and management of the interventions.

2.3 DATA EXTRACTION AND SYNTHESIS

The extracted data use qualitative and quantitative methods for NBS projects, with the aim of identifying trends, gaps, and main observations. The analysis focuses on:

- Research focus:** The main objectives of each study will be identified, categorising them as simulation and performance, implementation, or theoretical frameworks. This assists in the discovery of trends and gaps in the literature on NBS.
- Scale of impact:** Each study will be analysed according to the scale of impact of NBS (local, municipal, or regional). This categorisation will help to understand the reach and relevance of the interventions for urban contexts.

- c) Community participation: The level of community involvement in the implementation of NBS implementation projects will be observed and recorded, highlighting, where applicable, reports of active participation of residents or interested groups. This criterion is fundamental for evaluating public acceptance and the potential for appropriation of the interventions.
- d) Satisfaction evaluation: The methods used to measure satisfaction will be indicated, including the use of Likert scales, social well-being indicators, and specific criteria for public acceptance. These data will indicate how the interventions influence the perceptions and well-being experience of residents.

Post-occupancy evaluation aims to provide information about the factors that influence the successful implementation of NBS in urban planning and development. This research will focus on three main aspects:

- a) Perception vs. Post-Occupancy Evaluation: Identifying how expectations compare to actual impacts.
- b) Traditional Solutions vs. Innovative Nature-Based Solutions (NBS): Evaluating urban parks and street trees versus Green Roofs and Vertical Gardens.
- c) Economic and social impact: Evaluating how NBS influence property values, local commerce, and community engagement.

3 ANALYSES AND RESULTS

3.1 EVOLUTION OF RESEARCH ON NBS

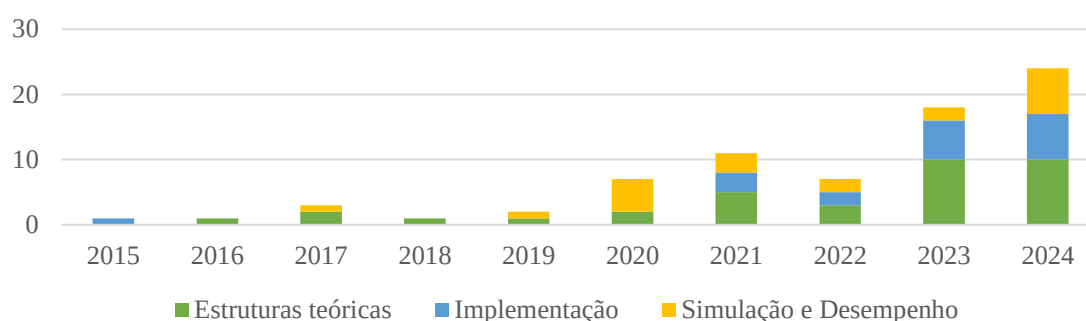
Despite the growth of research on NBS in recent years, most studies focus on the environmental impacts of these interventions, while issues related to user perception and experience still appear in a more limited way. Although there is a variety of research focused on the environmental, social, and economic effects of NBS, few works analyse how these spaces are used and incorporated into urban daily life after their implementation (Arnberger *et al.*, 2024; Collier *et al.*, 2023; Frantzeskaki *et al.*, 2019; Mahmoud *et al.*, 2024).

The oldest article identified in this review dates from 2015, a period subsequent to the launch of the Horizon 2020 programme, a European initiative aimed at encouraging research related to NBS and urban sustainability (Horizon Europe, 2023). From 2021 onwards, a more significant increase in the number of publications was observed, possibly associated with the observed consequences of the Covid-19 pandemic regarding the intensification of discussions related to climate change and environmental disasters. During this period, themes linked to urban environmental quality, green areas, and open spaces began to receive

greater attention in different urban contexts (Dawson *et al.*, 2024; Frantzeskaki *et al.*, 2019; Grobman *et al.*, 2023).

Figure 1

Distribution of research areas of interest over time



Source: prepared by the authors, 2026.

In this review, the analysed studies were organised into three main categories: theoretical frameworks, implementation, and simulation/performance.

Between 2015 and 2020, research focused on the theoretical frameworks of NBS predominated, totalling 31 articles. These studies contributed to the conceptual consolidation of green infrastructure in contemporary urban planning, especially in discussions related to sustainability, climate adaptation, and green infrastructure (Frantzeskaki *et al.*, 2019; Kampelmann, 2021; Muñoz-Pizza *et al.*, 2020).

From 2017 onwards, and more evidently after 2020, there was an increase in research related to the practical implementation of NBS in real urban contexts, totalling 22 articles. During this period, case studies, urban applications, and practical evaluations became more frequent, mainly in research related to urban drainage, thermal comfort, environmental quality, and the use of public spaces (Derickson *et al.*, 2024; Dreyer *et al.*, 2018; Grobman *et al.*, 2023; Mahmoud *et al.*, 2024).

The simulation and performance category gathered 15 articles focused on the evaluation of the environmental impacts of NBS through simulation tools and performance metrics. The studies in this category analyse factors associated with climate resilience, urban biodiversity, thermal comfort, and environmental sustainability (Ghazalli *et al.*, 2018; Pitman *et al.*, 2015; Santamouris & Osmond, 2020). Even so, much of this research remains concentrated on technical and environmental indicators, while elements involving user experience and social impacts appear less recurrently (Kampelmann, 2021; Muñoz-Pizza *et al.*, 2020).

3.2 ENVIRONMENTAL IMPACTS OF NBS

In the reviewed studies, NBS appear associated with different environmental gains in urban areas. Among the most recurrent effects are the reduction of heat islands, local thermal regulation, stormwater management, and support for urban biodiversity. Green infrastructure such as urban forests, green roofs, and vertical vegetation systems can contribute to these processes through the increase in vegetation cover, evapotranspiration, and shading, as well as the reduction of impermeable surfaces (Ghazalli *et al.*, 2018; Pitman *et al.*, 2015; Santamouris & Osmond, 2020; Berg *et al.*, 2024; Schneider *et al.*, 2024).

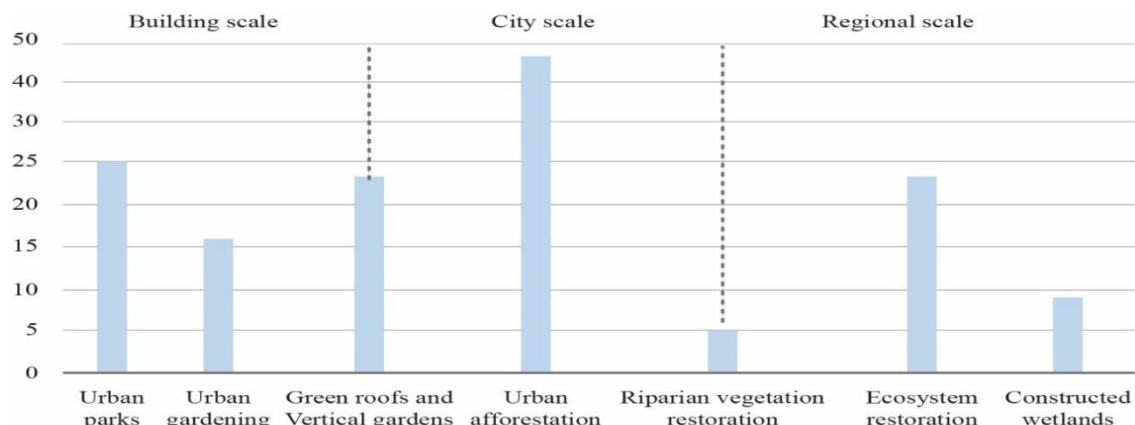
In the case of thermal regulation, the studies indicate that the presence of vegetation can reduce surface temperatures and improve microclimatic conditions in urban areas. This effect occurs more evidently in interventions with greater vegetation mass, such as urban forests and parks, but also appears in solutions applied at the building scale, such as green roofs and vertical gardens. In these situations, improvements tend to be more localised, contributing to immediate environmental comfort and, in some cases, to the reduction of building cooling energy demand (Ghazalli *et al.*, 2018; Santamouris & Osmond, 2020; Pitman *et al.*, 2015).

Water management also appears recurrently in the analysed literature. Permeable surfaces, rain gardens, and infiltration trenches contribute to increasing rainwater infiltration, reducing surface runoff, and decreasing pressure on urban drainage systems (Doll *et al.*, 2023; Fouad *et al.*, 2023; Virtudes, 2016; Tedesco *et al.*, 2019). Some of the studies also associate these strategies with the reduction of flood risks, the improvement of stormwater management, and assistance in aquifer recharge in urbanised areas (Fouad *et al.*, 2023; Doll *et al.*, 2023).

Another environmental benefit identified refers to urban biodiversity. The introduction of vegetation in urbanised areas can expand habitats, favour ecological connectivity, and support the presence of different plant and animal species. These effects are more evident in interventions that use native species or that are articulated with already existing ecological networks, such as green corridors, riparian restoration, and urban reforestation areas (Molari *et al.*, 2024; Rostami *et al.*, 2015; Berg *et al.*, 2024; du Toit *et al.*, 2018).

Figure 2

Distribution of research by nature-based strategies and their relationship with multiple environmental scales. Building Scale: Urban Gardens, Green Roofs and Vertical Gardens. City Scale: Urban Parks, Urban Reforestation. Urban Regional Scale: Riparian Vegetation Restoration, Ecosystem Restoration, Wetland Construction



Source: prepared by the authors, 2026.

The distribution presented in Figure 2 indicates that the analysed strategies operate at different environmental scales. Larger-scale interventions, such as urban reforestation, ecological restoration, and riparian vegetation restoration, tend to relate to broader processes of climate regulation, biodiversity conservation, and water management. Conversely, localised solutions, such as green roofs, vertical gardens, and urban gardens, present localised effects, but can be relevant in densely urbanised areas, where the availability of free land is reduced (Berg *et al.*, 2024; du Toit *et al.*, 2018; Schneider *et al.*, 2024).

The review demonstrates the predominance of isolated NBS implementation strategies. Among the analysed studies, 40 articles addressed single interventions, such as urban forests, green roofs, and rain gardens, representing approximately 59% of the sample. Meanwhile, 18 studies investigated interconnected solutions, combining different elements of green infrastructure, such as permeable pavements, vegetated corridors, and integrated urban drainage systems.

This difference is relevant because isolated interventions generally seek to solve specific and localised problems, while combined solutions allow the integration of multiple environmental functions in urban space. Among these functions are the improvement of drainage, the increase of shading, the expansion of habitats, and the strengthening of ecological connectivity. Thus, the studies indicate that interconnected systems tend to present greater potential for contributing to urban resilience and to the environmental performance of cities (C. Wang *et al.*, 2016; Tedesco *et al.*, 2019; Berg *et al.*, 2024; Schneider *et al.*, 2024).

3.3 SOCIAL AND ECONOMIC IMPACTS AND POST-OCCUPANCY EVALUATIONS OF NBS

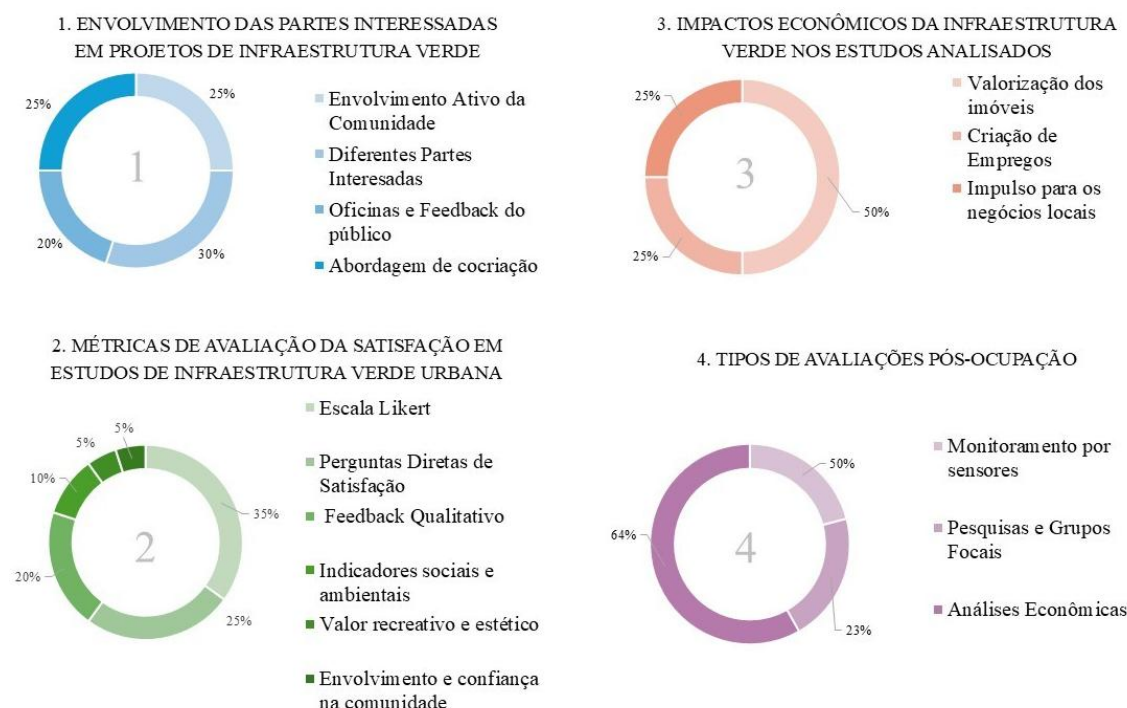
When analysing the impacts of NBS in urban contexts, it is observed that their effects vary according to the type of intervention, the implementation conditions, and the social, economic, and spatial characteristics of each locality. In the reviewed studies, aspects related to community participation, user perception, property valorisation, maintenance, and post-occupancy evaluation appear recurrently, indicating that the effects of these interventions go beyond exclusively environmental issues.

Part of the analysed research relates the implementation of urban green areas to the increase in community use of public spaces and the expansion of opportunities for social interaction. Urban parks, street trees, community gardens, and other interventions associated with green infrastructure frequently appear linked to people's permanence in urban spaces, leisure activities, and the perceived improvement in environmental quality (Megyesi *et al.*, 2024; Monteiro *et al.*, 2020; Rostami *et al.*, 2015; Semeraro *et al.*, 2024). In different contexts, these studies also associate such spaces with the improvement of the population's physical and mental well-being, especially in areas with lower availability of urban vegetation (Arnberger *et al.*, 2024; Dawson *et al.*, 2024).

Figure 3 presents a synthesis of the approaches identified in the reviewed studies, bringing together social, economic, and methodological aspects related to the evaluation of NBS in urban contexts. The graphic representation organises the results into four main axes: stakeholder involvement, user satisfaction metrics, economic impacts, and types of post-occupancy evaluation. These data are taken up and discussed in detail in the following paragraphs, based on the individual analysis of each axis presented in the figure.

Figure 3

Synthesis of the approaches analysed in the studies on urban green infrastructure, including stakeholder involvement, satisfaction metrics, economic impacts, and post-occupancy evaluation methods



Source: prepared by the authors, 2026.

Based on the synthesis presented in Figure 3, it is observed that the social, economic, and post-occupancy effects of NBS do not occur homogeneously. Some studies point out that certain strategies may contribute to processes of property valorisation and socio-spatial transformation, especially in regions subjected to recent urban requalification. In these situations, the increase in property value and in the cost of remaining in certain areas may affect more vulnerable populations, broadening discussions related to urban equity and the unequal distribution of the benefits produced by green infrastructure (Adegun *et al.*, 2022; Frantzeskaki *et al.*, 2019; Ring *et al.*, 2021; Tedesco *et al.*, 2019; Buijs *et al.*, 2024; Peroni; Pappalardo, 2024).

The implementation of NBS also appears directly related to the social, spatial, and cultural characteristics of each urban context. The reviewed studies indicate that interventions developed with greater attention to local dynamics tend to present greater public acceptance and better integration into the daily life of the population (Arnberger *et al.*, 2024; Berg *et al.*, 2024; Dawson *et al.*, 2024; Derickson *et al.*, 2024). In part of the analysed research, community participation contributed to identifying demands related to the use of spaces, accessibility, people's permanence, and the maintenance of green areas (Barron & Rugel, 2023; Fonteyn *et al.*, 2024).

Figure 3, Diagram 1, presents the results related to stakeholder involvement in green infrastructure projects. The forms of participation identified in the studies include direct community involvement, integration between different social actors, public workshops, and co-creation processes. Among the analysed works, 44% reported some level of community participation during the planning, implementation, or maintenance stages of the green infrastructure, while 56% did not address this aspect explicitly. The studies also indicate that more continuous participatory processes tend to be associated with higher levels of acceptance, appropriation, and use of the green spaces implemented by the local population (Arnberger *et al.*, 2024; Collier *et al.*, 2023; Fonteyn *et al.*, 2024; Fox-Kämper *et al.*, 2023).

However, the studies also point out limitations related to the continuity of participatory processes. In some contexts, difficulties associated with public management, reduced financial resources, and institutional barriers hindered the continuous involvement of the community after the initial implementation of green strategies (du Toit *et al.*, 2018; Barron & Rugel, 2023; Derickson *et al.*, 2024). Derickson *et al.* (2024), when discussing urban justice and green infrastructure in different international contexts, also point out that many urban greening projects present community participation limited to the initial stages of public consultation, without permanent mechanisms of shared governance after the implementation of the interventions. According to the authors, this frequently results in poorly representative processes and in the difficulty of maintaining the strategies in socially vulnerable areas.

Barron and Rugel (2023), when analysing green spaces aimed at the mental health of young adults, observed that the effectiveness of these interventions depended directly on the continuity of local management, maintenance of the spaces, and permanence of community actions after the initial implementation, indicating that the absence of continuous institutional support may compromise the use and social appropriation of these areas over time. In addition, part of the research highlights that socially vulnerable groups are not always able to participate equivalently in urban planning processes, mainly in contexts marked by socioeconomic inequalities and limited access to public participation mechanisms (Adegun *et al.*, 2022; Ring *et al.*, 2021).

Adegun *et al.* (2022) analysed and discussed vertical vegetation systems in low-income urban contexts in sub-Saharan African countries, and identified that the costs of installation, maintenance, and irrigation frequently hindered the implementation of these solutions in socially vulnerable communities. The authors also highlight that, in many cases, local urban priorities were associated with access to basic infrastructure, housing, and sanitation, reducing the viability of technically more complex green strategies in certain urban contexts.

Ring *et al.* (2021), when analysing the Green and Open Space Factor instrument in Vienna, observed that, although green infrastructure policies may contribute to expanding urban vegetated areas, the distribution of these benefits tends to occur unevenly between different regions of the city. The authors point out that areas subjected to greater urban investments frequently concentrate more qualified green interventions, while peripheral or socially vulnerable neighbourhoods may present less access to the environmental improvements associated with green infrastructure.

Ali *et al.* (2020), when investigating green regeneration processes in Leipzig, Germany, also identified relationships between the implementation of green areas and processes of property valorisation. The study shows that urban environmental interventions can simultaneously contribute to environmental improvements and socio-spatial transformations, especially in neighbourhoods subjected to recent urban requalification processes, broadening debates related to green gentrification and the permanence of the populations.

In addition to community participation, much of the analysed research also sought to understand how users perceive and use these solutions in daily life after their implementation. For this, the analysed studies used different methods of evaluating satisfaction and environmental perception.

Figure 3, Diagram 2, presents the metrics used to evaluate satisfaction in studies related to urban green infrastructure. Among the analysed works, 35% used Likert-type scales to evaluate aspects associated with environmental quality, accessibility, and perception of well-being in green spaces (Arnberger *et al.*, 2024; Rostami *et al.*, 2015; Semeraro *et al.*, 2024).

Arnberger *et al.* (2024), for example, applied structured questionnaires with scales aimed at analysing the perceived psychological benefits in different types of urban green areas by adolescents, university students, and adults. Among the aspects evaluated were the sensation of relaxation, stress reduction, sociability, perception of safety, and contact with nature. The results demonstrate that perception scales have been widely used to understand the relationship between users and urban green spaces, allowing the identification of different dimensions of the environmental experience and the well-being associated with these areas.

Direct questions about satisfaction appeared in 25% of the research, generally related to maintenance, comfort, and the recreational value of the interventions (Monteiro *et al.*, 2020; Schneider *et al.*, 2024). Schneider *et al.* (2024), for example, investigated the population's willingness to contribute to urban greening programmes, identifying relationships between environmental satisfaction, aesthetic perception, and public support for green interventions.

Other studies used open responses and qualitative feedback to understand experiences associated with the everyday use of green spaces (Dawson *et al.*, 2024; Megyesi *et al.*, 2024). Dawson *et al.* (2024), when investigating the preferences of immigrants in urban green areas in Sweden, identified that factors such as the sensation of safety, possibilities for social interaction, and cultural familiarity directly influenced the appropriation of these spaces.

Although much research is focused on temperature, urban drainage, or biodiversity, the continuous use and permanence of these infrastructures also depend on how the spaces are perceived and appropriated by the population (Collier *et al.*, 2023; Frantzeskaki *et al.*, 2019; Mahmoud *et al.*, 2024). Collier *et al.* (2023), for example, highlight that processes of planning, management, and shared maintenance directly influence the continuity of use of green infrastructure in urban contexts.

The reviewed studies also identified economic impacts associated with the implementation of green infrastructure in urban areas. Ali *et al.* (2020), when investigating green regeneration processes in Leipzig, Germany, identified relationships between the implementation of urban green areas and property valorisation in neighbourhoods subjected to urban requalification. Similarly, Lampinen *et al.* (2023) point out that policies related to green infrastructure are frequently associated with the environmental and economic valorisation of certain urban areas, although the observed benefits vary according to the socio-spatial context and the type of intervention implemented.

Figure 3, Diagram 3, presents the main economic impacts associated with green infrastructure in the analysed studies. Part of the research relates the presence of these interventions to property valorisation, the reduction of energy costs, and the economic dynamisation of certain urban areas (Buijs *et al.*, 2024; Peroni & Pappalardo, 2024; Lampinen *et al.*, 2023; Moffat *et al.*, 2024).

In addition, some studies point out that elements such as green roofs, vegetated areas, and sustainable urban drainage systems may contribute to reducing the energy demand for building cooling, as well as decreasing costs associated with stormwater management (C. Wang *et al.*, 2016; Tedesco *et al.*, 2019). Thus, the results indicate that green infrastructure may produce both direct and indirect economic effects, related not only to the valorisation of urban space, but also to the reduction of operational expenses and the improvement of the environmental conditions of cities.

However, the observed economic trends vary according to the type of intervention and the urban context analysed. Although part of the research associates NBS with the environmental valorisation of cities, some studies indicate that the effects may occur

unevenly, especially in areas subjected to processes of accelerated property valorisation (Frantzeskaki *et al.*, 2019; Ring *et al.*, 2021).

Post-occupancy evaluations also appear recurrently in the reviewed studies, mainly to understand how green interventions behave after their implementation in real conditions of use. As presented in Figure 3, Diagram 4, economic analyses were the most frequent approaches among the reviewed studies, corresponding to 64% of the identified methodologies. Sensor monitoring was present in 50% of the analysed research, being used mainly for the evaluation of temperature, air quality, energy efficiency, and urban biodiversity (Dreyer *et al.*, 2018; Mahmoud *et al.*, 2024; Natanian *et al.*, 2024; Widera, 2021).

In addition, perception surveys and focus groups also appeared among the methods employed to understand user satisfaction and the environmental perception related to urban green spaces (Ali *et al.*, 2020; Anderson & Gough, 2020). The results demonstrate that post-occupancy evaluation studies in green infrastructure combine quantitative and qualitative approaches, seeking to analyse both the environmental performance of the interventions and the experience and perception of users in relation to the implemented spaces.

The studies that address post-occupancy evaluations show important differences between traditional green interventions and more recent solutions. Urban parks and tree-lined streets tend to present more consistent community use over time, mainly due to accessibility and lower maintenance demands (Dreyer *et al.*, 2018; Natanian *et al.*, 2024; Rostami *et al.*, 2015; Santamouris & Osmond, 2020). On the other hand, green roofs and vertical gardens present more variable results, especially in contexts where there are limitations related to continuous maintenance, operational costs, and accessibility of the systems (Ghazalli *et al.*, 2019; Liu *et al.*, 2024; Wilby, 2007; Zhong *et al.*, 2024).

4 DISCUSSIONS

In summary, the analysed studies indicate a progressive growth of research on NBS in the urban context, moving from more conceptual approaches to practical applications, performance analyses, and post-occupancy evaluations. Even so, themes related to user perception, community participation, and everyday experiences associated with green spaces tend to receive less in-depth treatment when compared to environmental and technical analyses (Collier *et al.*, 2023; Fonteyn *et al.*, 2024; Mahmoud *et al.*, 2024).

Throughout the reviewed research, an expansion of interest in NBS was observed in discussions on urban planning, especially in view of the worsening of climate change, the sealing of cities, and the reduction of vegetated areas. However, the results found suggest that the effects of these interventions vary according to the context in which they are

implemented and should not be understood as universal responses to contemporary urban problems. The reviewed literature points out that interconnected strategies may expand benefits related to stormwater management, ecological connectivity, and support for urban biodiversity. Nevertheless, the results tend to depend on local conditions, design choices, the scale of implementation, and the continuity of maintenance over time (Adegun *et al.*, 2022; Tedesco *et al.*, 2019; Schneider *et al.*, 2024).

The analysed works also suggest that environmental benefits usually present greater stability when associated with interventions already incorporated into urban daily life, such as parks, street trees, and public green areas. These strategies frequently appear related to the improvement of thermal comfort, the expansion of permanence in public spaces, and the increase in opportunities for urban interaction. Even so, the distribution of these infrastructures occurs unevenly between different cities and regions. In many developing countries, including Brazil, there are still limitations related to the availability of public green areas, urban planning, and resources allocated to the implementation and maintenance of these strategies.

In addition, part of the research indicates that the acceptance of these interventions may be more linked to accessibility, ease of use, and integration into the urban routine than to the technical recognition of the NBS concept. In many cases, the population enjoys the benefits associated with vegetated areas without necessarily associating them with NBS. In contexts marked by reduced access to parks, squares, and qualified green infrastructure, post-occupancy evaluations themselves may present limitations, since part of the population has restricted contact with these spaces.

On the other hand, more recent solutions, such as green roofs and vertical vegetated systems, tend to present more variable behaviour. Although frequently associated with environmental innovation and climate adaptation, these interventions may require continuous maintenance, irrigation, specialised technical support, and prolonged financial resources. Ghazalli *et al.* (2019) highlight that the performance of these systems may depend directly on maintenance, the appropriate choice of plant species, and climate compatibility. In the Brazilian context, these solutions still appear in a relatively isolated way, often linked to isolated initiatives, institutional buildings, or higher economic standard developments, partly due to the costs involved and the low integration of these strategies into local urban policies. Even so, in densely urbanised areas, these systems may expand the possibilities of inserting vegetation in places with little availability of free land.

Another recurrent aspect refers to the difference between the benefits expected during planning and the effects observed after the implementation of green infrastructure. Part of

the studies suggests that expectations related to microclimatic improvement, environmental quality, and the social use of spaces may be broader in the initial phases of the projects than those verified later in real situations of use. This difference tends to become more evident in technically more complex vegetated systems, in which maintenance, vegetation replacement, irrigation, and operational costs come to directly influence the functioning of the interventions over time.

The analysed research also shows that the effects of NBS may be associated not only with the environmental performance of the interventions, but also with social, institutional, and economic factors. Issues related to community participation, public management, institutional capacity, and socioeconomic context tend to directly influence the permanence and use of these urban structures. In different studies, projects developed with greater local participation presented greater adequacy to the needs of residents and less resistance during implementation. Even so, participatory processes did not always occur in a continuous or representative way, mainly in contexts marked by social inequalities and limited access to public participation mechanisms.

The discussions on economic impacts also reveal contradictory situations. Although part of the literature associates green infrastructure with property valorisation, improvement of urban environmental quality, and reduction of energy costs, the observed effects vary according to the type of intervention and the context analysed. Ali *et al.* (2020), when investigating green regeneration processes in Leipzig, Germany, identified relationships between the implementation of green areas and property valorisation in neighbourhoods subjected to urban requalification. In these cases, environmental valorisation may occur simultaneously with the increase in the cost of permanence of local populations, broadening discussions related to green gentrification and the unequal distribution of environmental benefits.

The review also points out a recurrent imbalance in research on NBS. A large part of the studies focuses on technical and environmental indicators, such as temperature, urban drainage, biodiversity, and energy efficiency, while aspects related to the everyday experience of users, appropriation of spaces, and long-term social impacts remain less explored. This suggests that part of the evaluations on green infrastructure still considers environmental performance in a relatively isolated way, without fully incorporating the social and urban relationships that influence its permanence and use over time.

In general, the reviewed studies indicate that the effects of NBS may go beyond strictly environmental issues. The continuity of these strategies tends to depend on the social, economic, and institutional conditions present in each urban context. Thus, post-occupancy

evaluations become relevant because they reveal differences between the benefits expected during planning and what effectively occurs after implementation. In this sense, the combination of quantitative and qualitative methods may contribute to broader analyses, incorporating not only environmental indicators, but also issues related to everyday use, maintenance, and user perception.

5 CONCLUSIONS

The review carried out indicates that NBS have been assuming an increasingly present role in discussions on urban planning, climate change, and the environmental qualification of cities. However, the analysed studies also show that the effects of these strategies tend to vary according to the social, economic, climatic, and institutional context in which they are implemented. In countries such as Brazil, this discussion may still be considered controversial, mainly due to urban inequalities, infrastructure limitations, maintenance difficulties, and low continuity of public policies related to urban green areas.

Although there are already relevant examples of the implementation of urban parks, street trees, green roofs, and vegetated systems in different Brazilian cities, part of these initiatives still occurs in an isolated and unequal way. In many cases, the difficulties related to financing, continuous maintenance, and the integration of these strategies into urban planning may limit the permanence and performance of these interventions over time. In this sense, the review suggests that the advancement of NBS in the urban context may depend not only on the expansion of technical and environmental research, but also on the strengthening of more effective mechanisms of implementation, management, and post-occupancy monitoring.

The reviewed studies also indicate that aspects related to community participation, public perception, and everyday use of green infrastructure still appear in a less in-depth way in the literature when compared to environmental and technical indicators. In addition, in contexts marked by socio-spatial inequalities, part of the population may have limited access to the urban green areas themselves, hindering processes of participation, appropriation, and evaluation of these interventions.

Thus, the review points out the need for more complex and integrated urban diagnoses, capable of simultaneously considering environmental, social, economic, and institutional factors associated with NBS. The importance of expanding studies focused on post-occupancy evaluations, user perception, continuity of maintenance, and the effects of these strategies over time in different urban realities is also observed. In this sense, future research may contribute to a more in-depth understanding of the limitations, potentialities,

and contradictions associated with the implementation of NBS in cities marked by distinct urban contexts and socio-environmental inequalities.

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THE IMPORTANCE OF UNDERSTANDING THE EXPOSOME AND ITS APPLICATION IN PUBLIC HEALTH

A IMPORTÂNCIA DE COMPREENDER O QUE É O EXPOSOMA E A SUA APLICAÇÃO NA SAÚDE PÚBLICA

LA IMPORTANCIA DE CONOCER QUÉ ES EL EXPOSOMA Y SU APLICACIÓN EN LA SALUD PÚBLICA



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ABSTRACT

Introduction: The exposome, a concept introduced by Wild in 2005, encompasses the totality of exogenous and internal factors that a person experiences throughout their life and that influence their health or disease. **Objective:** To analyse what the exposome is and its importance in public health. **Methods:** A systematic documentary review was conducted using the PRISMA methodology in academic sources and artificial intelligence tools. It identifies its classification into general external, specific external, and internal domains; and describes measurement methods using biomarkers. **Results:** The importance of integrating multidisciplinary approaches and emerging technologies such as artificial intelligence for the identification, characterisation, and quantification of exposures is highlighted, in order to design more personalised preventive, diagnostic, and therapeutic strategies. **Conclusion:** The importance of early detection at different stages of life is recognised, taking into account the technical and methodological challenges of measuring complex exposures. Therefore, it is necessary to generate and develop open databases that strengthen public health.

Keywords: Exposome. Biomarkers. Public Health. Artificial Intelligence.

RESUMO

Introdução: O exposoma, conceito introduzido por Wild em 2005, abrange a totalidade dos factores exógenos e internos que uma pessoa experimenta ao longo da sua vida e que influenciam o seu estado de saúde ou doença. **Objectivo:** Analisar o que é o exposoma e a sua importância na saúde pública. **Métodos:** Realizou-se uma revisão sistemática do tipo documental, utilizando a metodologia PRISMA, em fontes académicas e ferramentas de inteligência artificial, identificando a sua classificação em domínios externo geral, externo específico e interno; descreve métodos de medição mediante biomarcadores. **Resultados:** Destaca-se a relevância de integrar abordagens multidisciplinares e tecnologias emergentes como a inteligência artificial para a identificação, caracterização e quantificação de

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exposições, com o fim de desenhar estratégias preventivas, diagnósticas e terapêuticas mais personalizadas. Conclusão: Reconhecer a importância da detecção precoce nas diferentes etapas da vida, tendo em conta os desafios técnicos e metodológicos para medir exposições complexas; pelo que é necessário ir gerando e desenvolvendo bases de dados abertas que fortaleçam a saúde pública.

Palavras-chave: Exposoma. Biomarcadores. Saúde Pública. Inteligência Artificial.

RESUMEN

Introducción: El exposoma, concepto introducido por Wild en 2005, abarca la totalidad de factores exógenos e internos que una persona experimenta a lo largo de su vida y que influyen en su estado de salud o enfermedad. Objetivo: Analizar qué es el exposoma y su importancia en la salud pública. Métodos: Se realizó una revisión sistemática de tipo documental, utilizando la metodología PRISMA, en fuentes académicas y herramientas de inteligencia artificial, identificando su clasificación en dominios externo general, externo específico e interno; describe métodos de medición mediante biomarcadores. Resultados: Se destaca la relevancia de integrar enfoques multidisciplinarios y tecnologías emergentes como la inteligencia artificial para la identificación, caracterización y cuantificación de exposiciones, con el fin de diseñar estrategias preventivas, diagnósticas y terapéuticas más personalizadas. Conclusión: Reconocer la importancia de la detección temprana en las diferentes etapas de la vida, tomando en cuenta los desafíos técnicos y metodológicos para medir exposiciones complejas; por lo que es necesario ir generando y desarrollando bases de datos abiertas que fortalezcan la salud pública.

Palabras clave: Exposoma. Biomarcadores. Salud Pública. Inteligencia Artificial.

1 INTRODUCTION

The exposome is a term coined by the epidemiologist Wild in 2005, which means the total addition of all exogenous and endogenous risk factors that a person perceives from birth to death, such as exposures to chemical and environmental substances, radiation, climate, environmental noise, stress, among others. As regards endogenous factors, these include lifestyle and health-related behaviours.

Studying the exposome of people is complex owing to its variability and the number of factors that interact throughout their life. Nevertheless, it is necessary to carry out an analysis in order to understand how risk factors contribute to health and/or disease. According to this analysis, it is possible to develop and design more personalised prevention and treatment strategies and therefore more effective ones for the individual.

It is worth mentioning that the exposome is dynamic, encompasses factors of diverse nature, and these may vary throughout life; an example of this may be one's socioeconomic status or level, physical and/or chemical agents, lifestyle habits, or the environment where the individual developed or lives.

The exposome can be classified according to three domains: general external, specific external, and internal.

The general external domain comprises social and psychological aspects such as social class, education; the psychological and mental state and the environment where the individual lives and/or carries out their daily activities.

The specific external domain contemplates radiation, environmental and chemical pollution, infectious-type microorganisms, diet, lifestyle (consumption of legal or illegal substances), occupation, among others.

The internal domain includes factors and processes such as: hormone levels, metabolism, body morphology (endomorph, mesomorph, ectomorph), physical activity, gut microbiota, epigenetics, etc.

In view of the above, it is necessary to analyse what the exposome is and its importance in public health.

2 METHOD

2.1 DESIGN AND PROTOCOL

The present research was developed through a systematic documentary review. To ensure the transparency, comprehensiveness, and reproducibility of the process, the guidelines of the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) were strictly followed. The study was oriented towards conceptualising the

exposome, identifying its domains, measurement methods, and current challenges in the field of health and education.

2.2 ELIGIBILITY CRITERIA (PICOS FRAMEWORK)

The selection of studies was based on the following eligibility criteria, structured under the acronym PICO:

- a) Population/Context: Individuals at any stage of the life course (from the prenatal stage to old age) in public health settings.
- b) Intervention/Phenomenon of interest: The concept of the exposome as the totality of non-genetic exposures (exogenous and endogenous factors).
- c) Comparator: Not applicable for this documentary review, although variations according to individual susceptibility and critical windows were analysed.
- d) Outcomes: Conceptual definitions, classification into domains, exposure/effect biomarkers, and the impact on the global burden of disease.
- e) Study designs: Observational studies, systematic reviews, reports from accredited health organisations, and original research articles.
- f) Additional inclusion criteria: Full-text articles, open access, published between 2020 and 2025, in Spanish and English, that included the keywords in the title.
- g) Exclusion criteria: Documents with restricted access, only abstracts, or those whose titles bore no direct relation to the object of study.

2.3 SOURCES OF INFORMATION AND SEARCH STRATEGY

A hybrid and exhaustive search strategy was employed, carried out between the years 2020 and 2025.

2.3.1 Traditional databases

High-impact databases were consulted: PubMed, Embase, Medline, SciELO, Cochrane Library, and Google Scholar. Controlled descriptors (DeCS and MeSH) and Boolean operators were used: exposome AND health AND disease.

2.3.2 Integration of Generative Artificial Intelligence (GAI)

To enhance the capacity for the discovery of grey literature and technical documents, GAI tools were integrated in the following manner:

Tools used: Large language models (LLMs) such as ChatGPT-4 and Perplexity Free were employed, together with platforms specialised in academic research such as TextCortex.com, Elicit.com, and semanticscholar.org.

Purpose: AI was used for the initial identification of sources, the synthesis of complex concepts, and the location of reports from international organisations (WHO, GBD) that often fall outside traditional bibliographic indexes.

Procedure (Prompting): A structured prompt designed to minimise hallucinations and maximise academic accuracy was applied: "Find academic documents (articles, reports, cases) on the exposome and its implication in health-disease in databases such as Cochrane, PubMed and Medline. Detail classification, measurement, importance and challenges".

2.4 STUDY SELECTION PROCESS

The selection flow was divided into four consecutive phases to minimise selection bias:

- a) Identification: Compilation of 9,650 total records from databases and AI.
- b) Screening: Removal of duplicates and review of titles/abstracts, resulting in 3,685 records.
- c) Eligibility assessment: Analysis of 160 full texts to verify compliance with the PICO criteria.
- d) Final selection: Inclusion of 48 articles that constituted the definitive corpus.

This process was carried out independently by the reviewers, resolving discrepancies through academic consensus.

2.5 DATA EXTRACTION AND SYNTHESIS

For the collection of information, a standardised extraction form was used that allowed the following elements to be tabulated: author/year, city or project, methodologies employed, exposures assessed, and main findings (predictive performance such as R²).

Data synthesis was carried out through thematic and comparative analysis. Owing to the heterogeneity of the studies (which range from biomonitoring to AI modelling), a quantitative meta-analysis was not performed, opting for a narrative synthesis that groups the findings into dimensions: conceptual, technical (biomarkers), technological (AI and GIS), and public policy.

2.6 QUALITY ASSESSMENT AND RISK OF BIAS

The validity of the conclusions was strengthened through the systematic refinement of the evidence, ensuring that the selected studies met the methodological requirements of the systematic approach proposed by PRISMA. Studies with robust methodological frameworks

(such as the HELIX and LEnS projects) were prioritised to ensure that the final synthesis reflects the state of the art with the least possible bias.

2.7 APPLICATION OF THE PRISMA METHODOLOGY

With the purpose of ensuring the transparency and reproducibility of the review process, the present study followed the guidelines established by the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The procedure was developed sequentially in four interrelated stages:

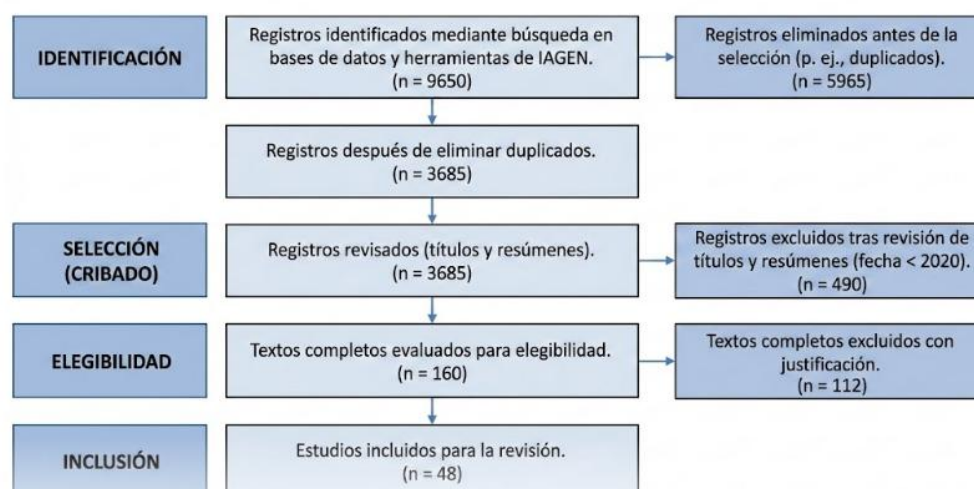
- a) Identification: Potentially relevant studies were compiled from the databases and generative artificial intelligence tools previously described, ensuring broad coverage of the sources.
- b) Screening: In this phase, duplicate records were removed and an initial review of titles and abstracts was carried out to discard works that bore no direct relation to the objectives of the research.
- c) Eligibility assessment: The full texts of the preselected studies were examined in detail, strictly applying the previously defined inclusion and exclusion criteria.
- d) Final selection: Only those documents that met all the methodological and thematic requirements were integrated, constituting the definitive corpus for the analysis and synthesis of the information.

This approach made it possible to systematically refine the available evidence, reducing selection bias and strengthening the validity of the conclusions derived from the study.

2.8 RESULTS OF THE SELECTION PROCESS

As a result of the initial search, 9,650 articles were identified and, after the rigorous application of the inclusion and exclusion criteria, the final sample comprised 48 articles.

The PRISMA flow diagram illustrating this process is presented below:

Figure 1*PRISMA 2020 flow diagram. Review of articles on the exposome*

Source: prepared by the authors.

3 RESULTS

3.1 EXPOSOME: CONCEPT, RELEVANCE, AND SCIENTIFIC FOUNDATION

The exposome integrates all the non-genetic exposures to which an individual is subjected from prenatal life to old age. This approach arises from the need to understand the burden of disease attributable to environmental, social, and biological factors. The WHO estimates that 24% of human diseases are attributable to non-genetic exposures, which evidences a wide margin for prevention. Likewise, the Global Burden of Disease identified that nine million annual deaths are related to air, water, and soil pollution, marking the urgency of mapping the human exposome.

The impact of these exposures depends on the dose, duration, timing of the exposure, and individual susceptibility. The physiological, endocrine, hormonal, and metabolic variations throughout life determine critical windows, especially during gestation (13) and childhood, where exposures can alter the developmental process with lifelong repercussions. (8,9)

3.2 MEASUREMENT OF THE EXPOSOME AND USE OF BIOMARKERS

The measurement of the exposome arises from the challenge of documenting internal and external exposures in a comprehensive manner. To this end, human and environmental biomonitoring strategies are employed, (14) which include analysis of blood, urine, (12) hair, teeth, nails, (15) placenta (16) and meconium. (16) These biospecimens make it possible to reconstruct short- and long-term exposures, taking into account specific chemical half-lives (for example, 15 h for chlorpyrifos in blood). (12)

Biomarkers are classified into:

- a) Exposure: which measures exogenous substances or their metabolites.
- b) Effect: which reflects the physiological or biochemical alterations associated with disease.
- c) Susceptibility: which determines the differential response to exposure.

And the omics sciences (genomics, proteomics, metabolomics) provide fundamental tools to discover new biomarkers and to characterise or identify the mechanism(s) of toxicity, although these face the challenge of capturing the heterogeneity, the inter-individual variability of the biological response. (24)

3.3 INTERNATIONAL PROJECTS TO STUDY THE EXPOSOME

The HELIX project (Human Early-Life Exposome) represents one of the most robust large-scale efforts to measure prenatal and postnatal exposures in European cohort studies. There, persistent and non-persistent organic compounds are assessed, such as: metals, pesticides, air quality, noise, UV radiation, and access to green spaces, integrated as indicators of childhood growth and health.

The Lifestage Exposome Snapshots (LEnS) (10) arises as a framework project that analyses exposures in target organs and by critical periods, making it possible to advance towards a more precise cartography of the human exposome.

3.4 CONTRIBUTIONS OF ARTIFICIAL INTELLIGENCE (AI) TO THE ANALYSIS OF THE EXPOSOME

AI constitutes a key advance for integrating multiple sources of environmental, biological, and geospatial data. Among the findings described:

- a) Neural networks and clustering algorithms (ANN, K-means, Fuzzy C-means) have managed to obtain predictions of atmospheric pollutants with good performance $R^2=0.7$. (18)
- b) Supervised models (SVM, KNN, Random Forest) have classified housing conditions as proxies of environmental exposure, which are indirect indicators used to estimate or reconstruct, with accuracies of 82–86% (19), past or present environmental exposures, and are especially of great support when direct measurements are not available.
- c) The integration of Geographic Information Systems (GIS), meteorological data, traffic, and surveys makes it possible to map critical points of urban exposure. (21) Likewise, it makes it possible to connect with other applications and data sources (such as HR, BIM, sensors) to combine spatial and non-spatial information, allowing deeper analyses.

These methods, applied in cities such as Buenos Aires, Salamanca, Jayllihuaya, and Bucharest, evidence the potential of AI to analyse complex exposures in real time and to support focused public policies. (20)

3.5 CHALLENGES IN THE ASSESSMENT OF THE EXPOSOME

The main limitations of the assessment of the exposome are:

- a) Difficulty in detecting substances with short half-lives.
- b) Lack of standardised and open databases of biospecimens that allow the development of better diagnoses and treatments, studying diseases, and training human resources.
- c) Major limitations in the qualitative and quantitative analysis of complex samples in the identification of thousands of substances detected by mass spectrometry.
- d) Complexity in carrying out multiple risk assessments that integrate environmental, biological, and social domains. (22, 23)

Nevertheless, advances in metabolomics and bioinformatics and AI promise to improve the precision of the characterisation of the exposome in the coming years.

Table 1

Relevant data from the included studies

City / Project	Methods or Technologies	Exposure assessed	Main findings / performance	Relevance for the exposome
Buenos Aires	Neural networks, clustering	Atmospheric pollutants (SO ₂ , PM10)	R ² =0.718 in pollutant forecasting	Improves prediction of urban exposures
Salamanca	Supervised algorithms (SVM, KNN, RF)	Housing conditions as an environmental proxy	Accuracy between 82–86.3%	Identifies dwellings with environmental risk
Jayllihuaya	GIS + data fusion	Multiple environmental risks	Identification of critical points	Allows interventions to be targeted
Bucharest	AI methods integrated with urban data	Environmental pollution and exposure conditions	Detection of vulnerable areas	Improves risk assessment in urban settings
HELIX (Europe)	Biomonitoring + sensors + omics	Prenatal and postnatal exposures (metals, pesticides, noise, air, UV, green spaces)	Associations with childhood growth and health	Establishes an early comprehensive framework of the exposome
LEnS	Target-organ models	Susceptibility windows	Mapping of the exposome by organ systems	More granular and transdisciplinary approach

Source: prepared by the authors.

The reviewed evidence demonstrates that the exposome constitutes an essential construct for understanding the global burden of disease attributable to non-genetic

exposures. The literature indicates that a significant proportion of human diseases ($\approx 24\%$) are preventable through the identification and mitigation of environmental, social, and biological factors, which supports the epidemiological value of the exposome throughout the life course.

The included studies show significant progress in the capacity to measure, integrate, and analyse multiple exposures through biomarkers, alternative biospecimens, and high-resolution analytical technologies. The omics sciences emerge as critical tools to characterise mechanistic pathways and to discover new exposure indicators, although the challenge of capturing individual variability in biological responses persists.

Artificial intelligence positions itself as a cross-cutting axis that enhances the assessment of the exposome through predictive algorithms, classification, spatial analysis, and fusion of heterogeneous data. The studies carried out in cities of Latin America and Europe evidence that AI improves the prediction of pollutants, identifies areas of urban risk, and makes it possible to develop more robust models of environmental exposure.

The HELIX and LEnS projects represent methodological references in the integration of biomonitoring, environmental sensors, and susceptibility-window approaches. These models make it possible to establish relationships between early exposures and childhood health outcomes, which reinforces the importance of intervening at critical stages of development.

The literature converges in indicating that the assessment of the exposome requires multidisciplinary approaches that integrate toxicology, epidemiology, nursing, medicine, and data science. It is important to mention that challenges persist, such as the need for open databases, harmonised methodologies, and analytical capacity to address multiple exposures with short half-lives. However, technological progress and the expansion of AI methodologies anticipate important improvements in the characterisation of the exposome and its application in public health policies.

4 DISCUSSION

The results obtained are consistent with international advances regarding the exposome and make it possible to critically contextualise its relevance, the methodological achievements attained, and the challenges that persist for its implementation in population research. The estimate that approximately 24% of the global burden of disease is attributable to non-genetic exposures fully coincides with the global reports of the WHO and the Global Burden of Disease, which have documented a substantial impact of air, water, and soil pollution on morbidity and mortality worldwide. The figure of around nine million annual

deaths attributed to environmental pollutants concurs with previous reports, which reinforces the urgency of integrating exposome methodologies to understand the complexity of such exposures.

The findings coincide with the literature where the importance of critical susceptibility windows is highlighted, mainly during gestation and childhood. Previous studies have documented physiological, endocrine, and metabolic variations that modulate vulnerability to chemical pollutants and environmental factors during these stages mainly (8, 9, 13). In this sense, the evidence reaffirms that early exposures can stimulate alterations with permanent repercussions on development, which is fully congruent with the results of international projects such as HELIX.

As regards the exposome measurement techniques, the results show a wide adoption of biomonitoring through blood, urine, hair, teeth, nail, placenta, and meconium samples, which coincides with international recommendations that mark the usefulness of diverse biospecimens to reconstruct short- and long-term exposures (12, 14–16). The classification of biomarkers such as: exposure, effect, and susceptibility are congruent with conceptual frameworks established in toxicology and environmental epidemiology, while the incorporation of omics technologies reflects the global trend towards the identification of early biological mechanisms and toxicity pathways (24).

With respect to the international projects, particularly HELIX and LEnS, they demonstrate a remarkable concordance with the literature by highlighting the importance of combining biomarkers, environmental sensors, GIS, and approaches based on critical stages of development. HELIX has been widely recognised as one of the most robust efforts to characterise prenatal and postnatal exposures of European cohorts; and the findings presented —such as the assessment of metals, pesticides, noise, air quality, and green spaces— fully coincide with its comprehensive approach. LEnS contributes an innovative approach through target-organ models, which aligns with the international trend towards a more granular cartography of the human exposome.

An outstanding contribution in the review is the integration of AI, whose results show various predictors similar to those reported in the global literature. The neural networks and clustering algorithms with R^2 values around 0.70 (18) are consistent with what has been observed in atmospheric modelling studies in other regions of the world. Likewise, the accuracy of 82–86% reported by supervised models such as SVM, KNN, and Random Forest (19) is comparable to what has been published internationally on the classification of environmental risks and the reconstruction of exposures in the absence of direct measurements. The additional evidence on the usefulness of GIS and data fusion to map

urban critical points (20, 21) concurs with studies in highly urbanised cities where AI has made it possible to identify vulnerable areas and design focused interventions.

Definitively, the challenges identified —difficulty in measuring substances with short half-lives, the lack of standardised databases, analytical limitations in mass spectrometry, and above all the complexity of multiple risk factors (22, 23)— are problems widely documented in the international literature. The difficulty in capturing and measuring dynamic and multifactorial exposures constitutes one of the most debated methodological terms in the exposome, this being a global problem. However, as various authors suggest, advances in metabolomics, bioinformatics, and AI offer diverse promising perspectives to reduce these gaps in the coming years.

The evidence of the results aligns with the trends identified in the international literature, which reinforces the importance of the exposome as a conceptual and methodological framework, and points to the need to continue strengthening the technical capacities, scientific infrastructure, and multidisciplinary efforts that allow its full application in public health and contemporary epidemiology.

5 CONCLUSION

The exposome has been consolidated as an essential framework for understanding the contribution of non-genetic exposures to the global burden of disease. The evidence agrees that a substantial part of chronic, developmental, and environmental pathologies can be prevented through the identification of risk factors, so that the measurement of and intervention on such exposures throughout the life course are fundamental for prevention. The methodological advances described —including biomonitoring through diverse biospecimens, the use of omics tools, environmental sensors, and high-resolution analytical models— allow the characterisation, in an increasingly precise manner, of the interactions between the environment and human biology.

Likewise, the integration of AI and GIS has emerged as a key and fundamental component for analysing complex exposures, predicting pollutants, and locating risk areas more efficiently. The international studies, particularly HELIX and LEnS, corroborate the relevance of critical susceptibility windows and demonstrate the value of comprehensive approaches that combine biological, environmental, and spatial data. These robust models offer a methodological precedent for future research, especially in contexts where multiple exposures and social factors interact dynamically.

However, despite the advances, important challenges still persist, such as: the limited capacity to measure substances with short half-lives, the lack of harmonised databases, the

analytical complexity of highly heterogeneous samples, and the need to address multiple risks simultaneously. Nonetheless, the accelerated progress in metabolomics, bioinformatics, and AI anticipates a favourable scenario for overcoming these limitations in the coming years.

The exposome represents a strategic opportunity to strengthen epidemiological research, guide evidence-based public policies, and promote more effective preventive interventions. Consolidating this perspective requires sustained investment in scientific infrastructure, interdisciplinary training, and collaborative efforts that make it possible to advance towards a more complete, equitable, and actionable understanding of the exposures that shape human health.

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PROSPECTIVE STUDY ON THE PRODUCTION OF MANUALS REGARDING THE BRAZILIAN "LEI DO BEM"

ESTUDO PROSPECTIVO ACERCA DA PRODUÇÃO DE MANUAIS SOBRE A LEI DO BEM

ESTUDIO PROSPECTIVO SOBRE LA ELABORACIÓN DE MANUALES ACERCA DE LA "LEI DO BEM"



10.56238/sevened2026.019-104

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ABSTRACT

This prospective study investigates the availability of educational and instructional manuals on the Brazilian "Lei do Bem" (Law No. 11,196/2005), specifically focused on the reality of Brazilian Scientific and Technological Institutions (STIs). The main objective is to support the originality and relevance of the proposal to develop a manual adapted to the needs of these institutions. The specific objectives were: to conduct a comprehensive documentary survey of existing materials; to identify informational and operational gaps in the application of the Lei do Bem within STIs; to substantiate the need for and originality of the proposed manual; and to suggest preliminary guidelines for its development. The methodology employed an exploratory prospective approach conducted through the gov.br portal, using the Access to Information Law (LAI) to consult Federal Higher Education Institutions (IFES) and Federal Institutes, as well as the Google Scholar platform. The results indicated a complete absence of consolidated and specific manuals on the Lei do Bem on the official websites of the consulted STIs. Existing references are limited to the legislation itself or to the Practical Guide issued by the Ministry of Science, Technology and Innovation (MCTI), whose focus is predominantly directed toward private companies and does not address the operational and pedagogical specificities of STIs. It is concluded that there is a critical institutional gap that reinforces the need for a modern, accessible educational product aligned with the specific demands of STIs, contributing to innovation in teaching and research institutions.

Keywords: Lei do Bem. Scientific and Technological Institutions (STIs). Innovation. Instructional Manual. Technological Forecasting.

RESUMO

O presente estudo prospectivo investiga a disponibilidade de manuais didáticos e orientativos sobre a Lei do Bem (Lei nº 11.196/2005), voltados especificamente para a realidade das Instituições Científicas e Tecnológicas (ICTs) brasileiras. O objetivo central é fundamentar a originalidade e a relevância da proposta de elaboração de um manual adaptado às necessidades dessas instituições. Como objetivos específicos, buscou-se: realizar prospecção documental abrangente sobre materiais existentes; identificar lacunas informacionais e operacionais na aplicação da Lei do Bem em ICTs; fundamentar a necessidade e originalidade do manual proposto; e sugerir diretrizes preliminares para sua

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elaboração. A metodologia empregou prospecção exploratória conduzida no portal gov.br, utilizando a Lei de Acesso à Informação (LAI) para consultar as Instituições Federais de Ensino Superior (IFES) e Institutos Federais, além da plataforma Google Acadêmico. Os resultados indicaram ausência total de manuais consolidados e específicos sobre a Lei do Bem nas páginas oficiais das ICTs consultadas. As referências existentes limitam-se à legislação ou ao Guia Prático do MCTI, cujo foco é predominantemente direcionado às empresas privadas, que não aborda as especificidades operacionais e pedagógicas das ICTs. Conclui-se que há lacuna institucional crítica que reforça a necessidade de um produto educacional moderno, acessível e alinhado às demandas específicas das ICTs, contribuindo para inovação nas instituições de ensino e pesquisa.

Palavras-chave: Lei do Bem. Instituições Científicas e Tecnológicas (ICTs). Inovação. Manual Orientativo. Prospecção Tecnológica.

RESUMEN

El presente estudio prospectivo investiga la disponibilidad de manuales didácticos y orientativos sobre la Ley del Bien (Ley n.º 11.196/2005), dirigidos específicamente a la realidad de las Instituciones Científicas y Tecnológicas (ICT) brasileñas. El objetivo central es fundamentar la originalidad y la relevancia de la propuesta de elaboración de un manual adaptado a las necesidades de estas instituciones. Como objetivos específicos, se buscó: realizar una prospección documental integral sobre los materiales existentes; identificar vacíos informativos y operativos en la aplicación de la Ley del Bien en las ICT; fundamentar la necesidad y originalidad del manual propuesto; y sugerir directrices preliminares para su elaboración. La metodología empleó una prospección exploratoria realizada en el portal gov.br, utilizando la Ley de Acceso a la Información (LAI) para consultar a las Instituciones Federales de Educación Superior (IFES) y a los Institutos Federales, así como la plataforma Google Scholar. Los resultados indicaron una ausencia total de manuales consolidados y específicos sobre la Ley del Bien en las páginas oficiales de las ICT consultadas. Las referencias existentes se limitan a la propia legislación o a la Guía Práctica del MCTI, cuyo enfoque está predominantemente dirigido a las empresas privadas y no aborda las especificidades operativas y pedagógicas de las ICT. Se concluye que existe una brecha institucional crítica que refuerza la necesidad de un producto educativo moderno, accesible y alineado con las demandas específicas de las ICT, contribuyendo a la innovación en las instituciones de enseñanza e investigación.

Palabras clave: Ley del Bien. Instituciones Científicas y Tecnológicas (ICT). Innovación. Manual Orientativo. Prospección Tecnológica.

1 INTRODUCTION

Brazilian Scientific and Technological Institutions (STIs) have established themselves as essential pillars for the country's development and economic growth, acting as catalysts for innovation and applied research (Mayrink, 2025). Within the scope of the National System of Science, Technology and Innovation (SNCTI), these institutions, which encompass universities and research institutes, hold a strategic role that transcends the mere production of knowledge, being responsible for a significant portion of national Research and Development (R&D), especially in collaboration with the productive sector.

The relevance of STIs lies in their capacity to generate intellectual capital, laboratory infrastructure and an environment conducive to the interconnection between academia and the market, elements that are crucial for competitiveness (Minghelli *et al.*, 2021).

The strategic function of STIs is particularly evident with regard to the raising of resources and institutional persuasion for investment in innovation. The Legal Framework for Science, Technology and Innovation (Law No. 13,243/2016) and the Lei do Bem itself (Law No. 11,196/2005) establish mechanisms that allow STIs to access extra-budgetary financial resources, whether through grants or through partnerships with companies seeking to benefit from tax incentives.

The technical expertise and credibility of these institutions are determining factors for success in attracting these investments, acting as a vector of trust that validates the quality and the commercial exploitation potential of R&D projects. However, the operationalisation of such resource-raising requires a clear command of the legal and procedural aspects, which is not always consolidated in internal administrative routines.

The lack of clear guidance on procedures for registering and benefiting from the Lei do Bem may result in the underutilisation of the resources available to STIs. The absence of standardised procedures also compromises institutional governance, rendering processes vulnerable to administrative failures and increasing compliance costs. It is estimated that federal institutions fail to raise significant resources owing to a lack of operational clarity, representing a direct loss of investments that could finance research and innovation.

The raising of resources for innovation by federal higher education institutions faces significant structural and cultural obstacles. Institutionally, the resource allocation criteria of agencies such as CNPq and Capes, by prioritising academic qualifications and publication volume, tend to favour regions with already-consolidated infrastructure, hindering access to new funding for institutions located in peripheral regions. Furthermore, "barriers" persist between academic work and private interest, especially related to the need for industrial secrecy and a prejudice regarding the alleged lack of objectivity of researchers (IPEA, 2010).

The IFES are frequently reduced to mere suppliers of qualified labour rather than technological risk partners. Finally, the chronic instability in the flow of resources, historically marked by contingency cuts in the Sectoral Funds, and the precariousness of the mechanisms for transmission between scientific knowledge and corporate technological application limit the effectiveness of universities in the national innovation dynamic (IPEA, 2010).

Currently, the strategic role of Scientific and Technological Institutions (STIs) in fostering innovation is closely linked to the increase in Intellectual Property (IP). According to data from the Statistical Yearbook of Industrial Property of the Instituto Nacional da Propriedade Industrial (INPI, 2024), the Brazilian IP system recorded a total of 27,701 patent applications in 2024, with 12,914 grants, while other IP categories grew significantly: trademark applications reached 444,037 (+10.3%), computer programmes grew by 25.5% and circuit topographies recorded 6 applications (+500%) (INPI, 2024).

STIs are major generators of invention patents and utility models, intangible assets that are fundamental for the protection of knowledge and its subsequent technology transfer to society.

The Lei do Bem, although fundamental, was conceived with a predominant focus on private companies taxed under the Real Profit regime. The prospecting carried out via the Access to Information Law (LAI) revealed a lack of specific educational materials on its application within STIs.

According to Cassiolato and Lastres (2019), the effective appropriation of fostering instruments depends on institutional capacities for interpreting and internalising regulatory requirements. The Practical Guide of the MCTI, although a reference document, does not address the operational, pedagogical and administrative specificities of STIs.

In view of the growing operational complexity that permeates the application of the Lei do Bem in institutional contexts, STIs face structural challenges in the effective implementation of these mechanisms. The Lei do Bem, originally conceived for private companies, requires reinterpretation when applied to public institutions, particularly regarding the eligibility of projects, fiscal documentation, contractual compliance and Intellectual Property management. This interpretative gap compromises the institutional capacity to operationalise the incentives in a safe and strategic manner.

In addition, STIs lack continuous institutional training adapted to the legal, fiscal and administrative complexity involved in managing projects under tax incentives, exposing themselves to audit risks and underutilising their innovation potential.

The concept of innovation has undergone profound transformations in recent decades, shifting from a linear model of technology transfer towards open, collaborative and mission-oriented paradigms (Plonski, 2017). In this new context, STIs assume a central role as articulators of the innovation ecosystem, which requires management instruments compatible with the complexity of contemporary university–enterprise interactions.

In view of this context, the present work prospects the absence of specific manuals on the Lei do Bem in STIs, identifies critical informational gaps in existing pedagogical materials and justifies the relevance and originality of a manual adapted to the managers and researchers of these institutions.

This proposition substantiates the need to translate technical-legal language into clear operational procedures, practical examples and management tools aligned with the institutional reality, thereby supplying internal training, strengthening innovation governance and broadening the effectiveness of public fostering policies within public teaching and research institutions.

The proposed manual, by establishing a practical path for the understanding and effective application of the Lei do Bem, constitutes an unprecedented and essential contribution to the process of institutionalising innovation in Scientific and Technological Institutions (STIs). Its conception aims to supply the gaps in knowledge and the lack of standardisation of procedures, ensuring that these institutions can exercise their strategic role with greater legal certainty and operational efficiency. In this way, the manual can maximise the impact of investments in Research and Development (R&D) on socio-economic development.

2 METHODOLOGY

The methodology adopted in this study combined exploratory research with technological research, aiming not only to deepen knowledge about the application of the Lei do Bem, but also to validate the precedence of the proposed manual, since this is a stage that verifies the non-existence of a similar product in the state of the art (Marques *et al.*, 2015; Procaci, 2016).

To this end, an exhaustive prospecting was carried out across all Federal Higher Education Institutions (IFES) and Federal Universities, covering at least one institution per state of the Federation. The search for information was conducted on the basis of the Access to Information Law (LAI), which ensured the appropriate rigour in verifying the transparency and public availability of the guidance materials.

In addition, a systematic search was carried out in Google Scholar with the descriptors "Lei do Bem" + "manual" and "Lei do Bem" + "ICT" (period 2015–2025, in Portuguese), in which no specific publication on a manual or operational guide for STIs was found.

Data collection was conducted during the period between April and December 2025, rigorously following the stages outlined in Table 1. The search terms for the prospecting were carefully adapted to the specific syntax of each search platform and of the institutional websites. For the organisation, cataloguing and processing of the collected data, the assistance of electronic spreadsheets was used.

Table 1

Description of the stages developed to carry out the precedence search study of digital manuals on the Lei do Bem

STAGE	DEFINITION OF ACTIVITIES
Definition of scope	Search for manuals related to the Lei do Bem for STIs
Definition of the research databases	Database used for searching terms in Portuguese: Fala.Br platform; Google Scholar
Definition of the search terms	"Lei do Bem" "manual"
Tabulation of search results	Organisation and processing of data in electronic spreadsheets
Tabulation of search results	Organisation and processing of data in electronic spreadsheets.
Quantitative analysis of the data	On the existence of manuals and legislation related to the Lei do Bem.
Export of documents	Preserve and cite evidence

Source: prepared by the author, 2025.

The method employed, which uses official documents and governmental sources for analysis, is classified as qualitative documentary research of national scope with a focus on Technological Forecasting, using primary governmental sources. The search was directed to the SouGov.br system, by means of requests based on the Access to Information Law (LAI) (Law No. 12,527/2011), which confers rigour and public endorsement to the data collection. This approach, which uses official documents and governmental sources for analysis, is validated by authors such as Kripka *et al.* (2015) and Yin (2015), who highlight the importance of qualitative documentary research for understanding practices and regulations, with an emphasis on traceable primary sources and stratified purposive sampling.

The scope included the verification of the availability of manuals on the Lei do Bem in IFES and Federal Institutes, with a sample of one institution per state. In the case of the Federal Institutes, the consulted unit was adopted as representative of the totality of the

institutes of the respective federative unit, thereby encompassing the regional diversity of the Federal Network of Professional, Scientific and Technological Education.

The data collection for this study began with the sending of formal requests to the analysed institutions, with the following query: "I request information regarding the existence of manuals, guides or any other official document that guides the application of the Lei do Bem (Law No. 11,196/2005) in the research, development and innovation activities promoted by the institution." From these responses, the available informational bases were identified and analysed, described below according to their main characteristics and relevance to the research.

The consultation of the Gov.br system was carried out through the protocol of formal requests on the Fala.BR platform – Integrated Ombudsman and Access to Information System, as set out in Table 2. Each request was directed individually to the selected institutions, ensuring traceability and an official response. After submission, the responses were monitored within the legal deadlines established by the LAI, allowing the systematisation of the documents and information provided by the consulted entities.

Table 2

Consultation of STIs

Database	Search term	Universities	Institutes	Manuals
Fala.BR	"I request information regarding the existence of manuals, guides or any other official document that guides the application of the Lei do Bem (Law No. 11,196/2005) in the research, development and innovation activities promoted by the institution"	27	27	0
TOTAL		54		0

Source: prepared by the author, 2025.

3 RESULTS

3.1 DOCUMENTARY PROSPECTING

The documentary prospecting was conducted in a comprehensive manner, covering 54 Higher Education Institutions (HEIs), being at least one Federal University per federative unit of Brazil, complemented by consultations with Federal Institutes of higher-level Education

in different states. This approach ensured representative coverage of the National System of Higher Education and of the Federalised Teaching System, providing a consolidated view of the Brazilian institutional reality regarding the availability of guidance materials on the Lei do Bem.

The results of the prospecting, carried out through the gov.br portal and instrumentalised by the Access to Information Law (LAI), revealed a critical finding: the complete non-existence of any consolidated, specific and institutionalised manual on the application of the Lei do Bem in the consulted STIs, as can be seen in Table 3:

Table 3

Description of the STIs consulted

REGION	INSTITUTIONS	TOTAL
NORTH	UFAM • UFAC • UFPA • UFRR • UNIR • IFAM • IFAC • IFAP • IFPA • IFRR • IFRO	8
NORTHEAST	UFAL • UFBA • UFC • UFPB • UPE • UFPI • UFRN • IFAL • IFBA • UFMA • IFPB • IFPE • IFPI • IFRN	15
CENTRAL-WEST	UNB • UFG • UFMT • UFMS • IFB • IFG • IFMT • IFMS	6
SOUTHEAST	UFES • UFMG • UFRJ • UNIFESP • IFES • IFMG • IFRJ • IFSP • IFR	16
SOUTH	UFPR • UFRGS • UFSC • IFPR • IFRS • IFSC	7
DF	UnB • IFB	2

Source: prepared by the author, 2025.

The 54 higher education institutions and the Federal Institutes analysed do not possess, on their official websites or institutional management platforms, standardised educational materials that address the operational, fiscal and administrative complexities of Law No. 11,196/2005 in the context of public institutions. The available references are limited to the Practical Guide of the Ministry of Science, Technology and Innovation (MCTI), which maintains a predominant focus on private companies, not addressing the specificities of public STIs.

This finding unequivocally reinforces the pertinence and originality of developing a manual directed at STIs as an unprecedented and necessary contribution to strengthening innovation actions in public teaching and research institutions. The scope of the prospecting, which included all Brazilian federative units through their federal universities, complemented

by higher-level federal institutes, validates the universality of the identified gap, confirming that the problem is not localised, but structural in the higher education system.

3.2 GAPS IDENTIFIED

Additionally, it is found that, in the responses provided by the universities and federal institutes through Fala.BR, the mentions of Law No. 11,196/2005 (Lei do Bem) are limited to citing the legislation as a regulatory reference or to indicating the Guide of the Ministry of Science, Technology and Innovation (MCTI) as guidance material. Such responses, however, are not accompanied by their own materials, adapted to the specificities of the Scientific and Technological Institutions (STIs), nor by pedagogical approaches that facilitate the understanding and practical application of the legal provisions by researchers, managers and innovation centres.

This exclusive dependence on external documents, devoid of institutional contextualisation and operational examples, evidences a formative gap of a manual with accessible, didactic content aligned with the specific demands of STIs (for examples, see Figures 1 and 2).

Figure 1

Consultation of STIs via Fala.BR (IFBA)

gov.br | Controladoria-Geral da União

Fala.BR
Plataforma Integrada de Ouvidoria e Acesso à Informação

> Principal > Detalhes do Pedido de Acesso à Informação

Detalhes do Pedido de Acesso à Informação

Consulte aqui os detalhes do pedido de acesso à informação selecionado

Ir para
Selecione a seção

^ Informações da Resposta

^ Data da resposta: 15/05/2025, às 11:38

Tipo	Responsável pela resposta	Destinatário recurso 1ª instância	Prazo para recorrer
Resposta Conclusiva	Pro-Reitor de Pesquisa, Pós-Graduação e Inovação	Chefe de Gabinete da Reitoria	26/05/2025 23:59

Decisão	Especificação da decisão
Informação Inexistente	-

Resposta
Prezado(a) cidadão(a),

Cumprimentamos cordialmente, em atenção ao disconto no pedido de acesso à informação NUP 23546.040871/2025-61, referente a existência de manuais, guias ou qualquer outro documento oficial que oriente à aplicação da Lei do Bem (Lei nº 11.196/2005); após consulta a Pró-Reitoria de Pesquisa, Pós-Graduação e Inovação e ao Polc de Inovação de Salvador informamos que os referidos setores não tem conhecimento sobre a existência de manuais, guias ou qualquer outro documento oficial que oriente a aplicação da Lei do Bem (Lei nº 11.196/2006) nas atividades de pesquisa, desenvolvimento e inovação promovidas pelas Instituições.

Estamos à disposição para quaisquer esclarecimentos necessários.

Atenciosamente,
Gestora do Serviço de Informação ao Cidadão do IFBA

Source: fala.BR, 2025.

Figure 2

Consultation of STIs via Fala.BR (UFMG)

gov.br Controladoria-Geral da União

Fala.BR Plataforma Integrada de Ouidoria e Acesso à Informação

Principal > Detalhes do Pedido de Acesso à Informação

Detalhes do Pedido de Acesso à Informação

Consulte aqui os detalhes do pedido de acesso à informação selecionado

Ir para

Selecione a seção

Informações da Resposta

Data da resposta: 15/05/2025, às 11:38

Tipo	Responsável pela resposta	Destinatário recurso 1ª instância	Prazo para recorrer
Resposta Conclusiva	Pro-Reitor de Pesquisa, Pós-Graduação e Inovação	Chefe de Gabinete da Reitoria	26/05/2025 23:59

Decisão	Especificação da decisão
Informação Inexistente	-

Resposta

Prezado(a) cidadão(a),

Cumprimentamos cordialmente, em atenção ao discosto no pedido de acesso à informação NUP 23546.040871/2025-61, referente a existência de manuais, guias ou qualquer outro documento oficial que oriente a aplicação da Lei do Bem (Lei nº 11.196/2005); após consulta a Pró-Reitoria de Pesquisa, Pós-Graduação e Inovação e ao Polc de Inovação de Salvador informamos que os referidos setores não tem conhecimento sobre a existência de manuais, guias ou qualquer outro documento oficial que oriente a aplicação da Lei do Bem (Lei nº 11.196/2006) nas atividades de pesquisa, desenvolvimento e inovação promovidas pelas Instituições.

Estamos à disposição para quaisquer esclarecimentos necessários.

Atenciosamente,
Gestora do Serviço de Informação ao Cidadão do IFBA

Source: fala.BR, 2025.

As can be seen in Figure 2, UFMG explicitly states the non-existence of manuals, guides or official documents on the application of Law No. 11,196/2005 (Lei do Bem) within the scope of CTIT and, through PROPLAN, affirms that it does not have its own guidelines on the understanding that, owing to tax immunity, the law's tax incentives would not apply directly to the University. This framing reveals a partial understanding of the potential for benefiting from the Lei do Bem from the University's perspective, as it is limited to merely tax issues, disregarding the systemic benefit for society and for the partner companies that invest in R, D&I with the STIs.

Although useful for accounting routines, the internal material cited (on companies' tax withholdings) is instrumental and restricted and does not replace the production of original and pedagogical content that translates the legal provisions into procedures, flows and

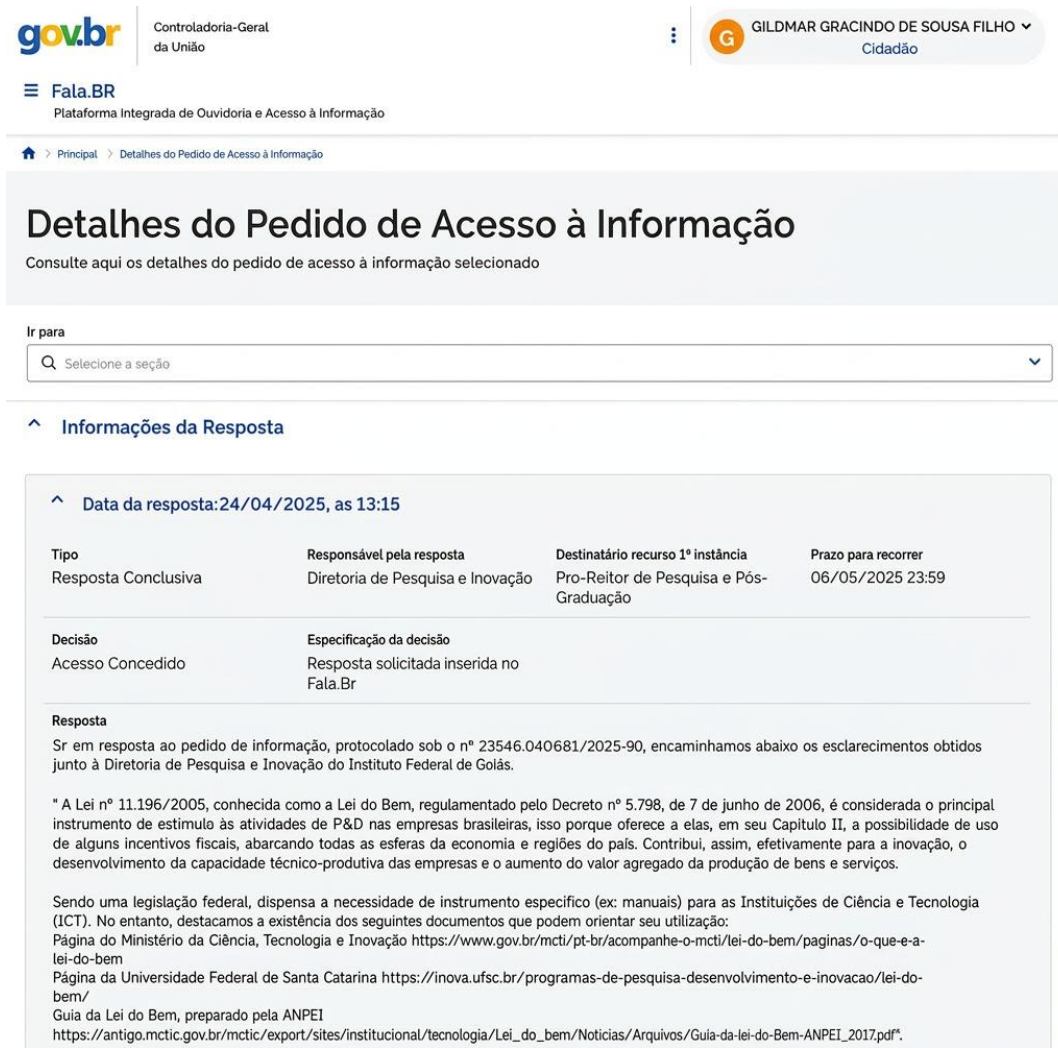
operational examples for cooperative projects (such as contracting and agreement templates, proof of eligible expenditure, metrics/TRL, evidence of results, governance and compliance).

This scenario is especially critical considering that innovation incentives in Brazil have already demonstrated a positive impact on the innovative performance of beneficiary companies, with an increase in R&D expenditure and a greater propensity to patent (Kannebley Jr.; Porto, 2012). The existence of proven corporate demand for cooperative projects with STIs makes the operational gap even more pressing: the instrument works, but the institutions lack the capacity to translate it into routines.

By disregarding the Lei do Bem as a public policy instrument for inducing private investment in R, D&I, strengthening cooperation between university and enterprise and generating positive externalities (intellectual property, productive linkages, technological diffusion), the institutional response reinforces the gap of contextualisation and didactic mediation that a specialised manual proposes to supply with accessible, applied guidelines aligned with the specific demands of STIs. Figure 3 presents another example of the current national scenario.

Figure 3

Consultation of STIs via Fala.BR (IFSC)



gov.br Controladoria-Geral da União

Fala.BR
Plataforma Integrada de Ouvidoria e Acesso à Informação

Principal > Detalhes do Pedido de Acesso à Informação

Detalhes do Pedido de Acesso à Informação

Consulte aqui os detalhes do pedido de acesso à informação selecionado

Ir para
Selezione a seção

Informações da Resposta

^ Data da resposta: 24/04/2025, as 13:15

Tipo	Responsável pela resposta	Destinatário recurso 1ª instância	Prazo para recorrer
Resposta Conclusiva	Diretoria de Pesquisa e Inovação	Pro-Reitor de Pesquisa e Pós-Graduação	06/05/2025 23:59

Decisão	Especificação da decisão
Acesso Concedido	Resposta solicitada inserida no Fala.Br

Resposta

Sr em resposta ao pedido de informação, protocolado sob o nº 23546.040681/2025-90, encaminhamos abaixo os esclarecimentos obtidos junto à Diretoria de Pesquisa e Inovação do Instituto Federal de Goiás.

"A Lei nº 11.196/2005, conhecida como a Lei do Bem, regulamentado pelo Decreto nº 5.798, de 7 de junho de 2006, é considerada o principal instrumento de estímulo às atividades de P&D nas empresas brasileiras, isso porque oferece a elas, em seu Capítulo II, a possibilidade de uso de alguns incentivos fiscais, abarcando todas as esferas da economia e regiões do país. Contribui, assim, efetivamente para a inovação, o desenvolvimento da capacidade técnico-produtiva das empresas e o aumento do valor agregado da produção de bens e serviços.

Sendo uma legislação federal, dispensa a necessidade de instrumento específico (ex: manuais) para as Instituições de Ciência e Tecnologia (ICT). No entanto, destacamos a existência dos seguintes documentos que podem orientar seu utilização:

Página do Ministério da Ciência, Tecnologia e Inovação <https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/lei-do-bem/paginas/o-que-e-a-lei-do-bem>

Página da Universidade Federal de Santa Catarina <https://inova.ufsc.br/programas-de-pesquisa-desenvolvimento-e-inovacao/lei-do-bem/>

Guia da Lei do Bem, preparado pela ANPEI https://antigo.mcti.gov.br/mctic/export/sites/institucional/tecnologia/Lei_do_bem/Noticias/Arquivos/Guia-da-lei-do-Bem-ANPEI_2017.pdf.

Source: fala.BR, 2025.

It is observed that the majority of Federal Higher Education Institutions (IFES) and Federal Institutes (IFs) resort, almost exclusively, to official documents, such as the Practical Guide of the Lei do Bem of the MCTI, Decree No. 5,798/2006 and Law No. 11,196/2005, in order to understand and apply the mechanisms of tax incentives for innovation.

Although indispensable as a regulatory basis and general guidance, such references possess a predominantly technical-prescriptive language and little dialogue with the operational and pedagogical specificities of the STIs' routine. The result is an asymmetry between "what the standard requires" and "how to operationalise" within the institutions, especially when there is cooperation with the productive sector.

This dependence on external sources signals a deficit of institutional didactic mediation. In terms of innovation management, this translates into difficulties in standardising procedures, qualifying evidence and building internal capacities.

As argued by Cassiolato and Lastres (2019), the effectiveness of innovation policies requires more than the existence of legal instruments: it requires the institutional capacity to interpret, adapt and internalise these instruments. The absence of original educational materials in the universities and federal institutes evidences limits in this learning trajectory, indicating that the regulatory internalisation of the Lei do Bem is still incipient and poorly systematised.

This gap reduces the strategic capacity of STIs to mobilise tax incentives, affecting the diffusion of knowledge, the articulation with companies and the effectiveness of public policies. In practical terms: without translating technical-legal requirements into routines, tools and management evidence, traction is lost in the qualified use of the instrument; hence the urgency of original, contextualised and practice-oriented content.

3.3 INSTITUTIONAL CAPACITY-BUILDING FOR OPERATIONALISING THE LEI DO BEM: BRIDGING THE GAP BETWEEN STANDARD AND PRACTICE IN STIS

The MCTI Guide standardises incentives at a high level, but its regulatory focus limits direct application in STIs with the productive sector. A manual is needed to complement it, translating technical-legal language into operational procedures, practical examples and adapted tools. This manual aims to promote regulatory internalisation, procedural compliance and the strategic use of the Lei do Bem via evidence trails, decision flows, checklists and institutional templates, reducing interpretative uncertainties.

Aligning with international and national recommendations, the OECD (2019, p. 01) emphasises that "changing citizens' expectations of governments requires new forms of engagement, better and more tailored services and policies that deliver better outcomes", concluding that governments "need to innovate". These guidelines converge on the need to strengthen governance, management and internal capacities in STIs, under penalty of underutilising the existing instruments. In this context, the construction of institutional pedagogical materials becomes a crucial component of the effectiveness of public policies, by translating technical-legal requirements into routines, tools and operational evidence applicable to the daily life of organisations.

As previously stated, a scarcity of educational materials specifically aimed at the application of the Lei do Bem within STIs was found. The only initiative identified is the e-book published by UFES in 2025, whose priority focus is to guide private companies on benefiting from the incentives, addressing the institutional specificities of STIs executing or partnering in R&D in a limited manner (Gracia; Zanotti, 2025). Added to this is the fact that the legislation (Law No. 11,196/2005, Chap. III) and Decree No. 5,798/2006 were conceived

with a preponderant focus on companies, and the MCTI Guide itself reinforces this bias by privileging the accounting and technical proof on the corporate side.

This combination of regulatory and operational gaps hinders the institutional appropriation of the Lei do Bem by the STIs, limiting their potential contribution to the innovation ecosystem. Hence the pertinence of a manual that internally builds the capacity of STIs and strengthens their strategic action in this instrument.

4 FINAL CONSIDERATIONS

Despite the relevance of Law No. 11,196/2005 (Lei do Bem) as an instrument for inducing R, D&I, the Scientific and Technological Institutions (STIs) lack their own pedagogical and operational materials that translate the standard into institutional routines. In light of this diagnosis, the foundations of a practical, accessible manual aligned with the management specificities of STIs are proposed, in order to reduce interpretative uncertainties, qualify compliance and broaden the strategic use of the instrument. Correlatively, the aim was to map, through documentary prospecting via LAI/FalaBR, the existence of manuals, guides and internal flows applied to the Lei do Bem in universities and federal institutes.

The responses via FalaBR converge towards a pattern of strictly regulatory response (Law, Decree and MCTI Guide) without operational didactic mediation, in addition to the absence of original content detailing eligibility, documentation, R, D&I governance, evidence trails and decision flows.

Responses such as that of UFMG reveal a restricted understanding of the scope of the Lei do Bem, limited to its direct inapplicability as an immune entity, disregarding the systemic potential of the instrument to enable cooperative partnerships with the productive sector. The only initiative mapped, the e-book of UFES (2025), guides private companies and does not cover the institutional routines of the STIs.

The set of findings indicates a structural gap, with low regulatory internalisation and limited mobilisation of incentives. This scenario raises the risks of disallowances, hinders the auditability of R, D&I expenditure and delays the diffusion of compliance practices. It is therefore imperative to prepare original technical-pedagogical materials that translate the standard into operational procedures, documentary templates and decision flows, strengthening innovation governance and the execution capacity of STIs.

The results dialogue with the literature and with institutional guidelines: the effectiveness of innovation policies depends on the organisational capacity to interpret, adapt

and internalise legal instruments (Cassiolato & Lastres, 2019), while the OECD (2019) emphasises governance, capacity-building and accountability as conditions for public impact.

In this context, a specific manual for STIs would fulfil the critical function of technical-pedagogical mediation, translating legal-accounting language into operational procedures, checklists, evidence trails, decision flows and documentary templates adherent to the routines of cooperative projects and to the management of Intellectual Property. It would be a knowledge management artefact capable of ensuring compliance, reduction of audit risks, acceleration of decision-making and alignment of internal actors (managers, researchers, support areas).

5 FUTURE PERSPECTIVES

The diagnosis presented confirms a structural gap in innovation management in STIs. As a development of this study, the production of a technical-pedagogical manual aimed specifically at Scientific, Technological and Innovation Institutions (STIs) is proposed, with a focus on the operationalisation of Law No. 11,196/2005 in university–enterprise cooperation contexts. The proposal consists of preparing an applied instrument, capable of translating the legal-accounting provisions of the Lei do Bem into operational flows, documentary templates, evidence trails, compliance checklists and practical guidelines adapted to the institutional routines of STIs.

A relevant perspective consists of the empirical validation of the proposed material in real institutional environments, through pilot projects conducted in federal universities and federal institutes. Such a stage would allow the impact of the manual on indicators such as the reduction of interpretative uncertainties, the standardisation of procedures, the strengthening of innovation governance, the improvement of the auditability of R, D&I expenditure and the broadening of the institutional capacity to interact with partner companies to be assessed.

It is also recommended to deepen comparative research between national STIs and international models of innovation management and tax incentives for research and development, especially in OECD member countries. Studies of this nature may contribute to the identification of institutional good practices related to regulatory internalisation, evidence management, compliance in cooperative projects and technology transfer mechanisms.

Another promising agenda involves the integration of digital solutions and intelligent platforms to support innovation management, including document management systems, automation of procedural flows and digital environments for continuous capacity-building. The

incorporation of digital technologies may broaden the accessibility of the guidelines, reduce informational asymmetries and strengthen the institutional culture of compliance and innovation.

Additionally, it is suggested to investigate the impacts of the absence of technical-operational capacity-building on the effectiveness of public innovation policies in Brazil, considering aspects such as the underutilisation of tax incentives, barriers to STI–enterprise cooperation, accountability difficulties and risks of disallowances in audits. Such investigations may support public policies aimed at strengthening the institutional capacities of STIs and broadening the effectiveness of the Lei do Bem as a strategic instrument for inducing the scientific, technological and economic development of the country.

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REGENERATIVE THERAPIES IN EQUINE ASTHMA: BIOLOGICAL BASIS AND CLINICAL APPLICATIONS

TERAPIAS REGENERATIVAS NA ASMA EQUINA: BASES BIOLÓGICAS E APLICAÇÕES CLÍNICAS

TERAPIAS REGENERATIVAS EN EL ASMA EQUINA: BASES BIOLÓGICAS Y APLICACIONES CLÍNICAS



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ABSTRACT

Equine asthma is a chronic respiratory disease with no known cure that, if not adequately treated, may worsen over time and with the degree of exposure to allergens and pathogens. It is characterised by bronchoconstriction and mucus hypersecretion, resulting in respiratory distress and potentially leading to pulmonary remodelling. It is currently classified as mild to moderate asthma (mEA) and severe asthma (sEA), depending on the clinical manifestation presented. Conventional treatment involves the use of corticosteroid anti-inflammatory drugs, bronchodilators and management. Although these treatments are comprehensive and effective, they only control the clinical signs and do not control inflammation over long periods, since they always depend on medication, nutritional care and environmental measures. Regenerative medicine, however, may have more prolonged effects on the inflammatory process and on pulmonary remodelling, aiming at tissue repair and regeneration. Among the available therapies, acellular ones stand out, such as platelet-rich plasma (PRP), alpha-2-macroglobulin (A2M), interleukin-1 receptor antagonist protein (IRAP) and prolotherapy, in addition to cell-based therapies based on mesenchymal stem cells (MSCs). Cell-based therapies are able to stimulate the release of a set of bioactive molecules, the secretomes, composed of cytokines, growth factors, proteins, exosomes and extracellular vesicles. These products exhibit immunomodulatory, anti-inflammatory and regenerative properties, favouring the reduction of oxidative stress, cell apoptosis and pulmonary inflammation. Cell-free therapies, in turn, may exhibit the same immunomodulatory effects but offer advantages such as greater ease of storage, lower immunological risk and greater standardisation compared with the direct use of the cells. Studies in horses demonstrate that the intratracheal administration of bone marrow-derived mononuclear cells and of adipose tissue-derived MSCs reduces pulmonary inflammation, attenuates the clinical signs and modulates the production of inflammatory cytokines. Despite the promising results, challenges persist regarding the standardisation of protocols, cell characterisation, definition of doses, routes of administration and specific regulation. Thus, regenerative medicine represents an innovative and promising therapeutic alternative for equine asthma, although its clinical consolidation depends on further studies that prove its safety, efficacy and reproducibility.

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Keywords: Regenerative Medicine. Cell Therapy. Cell-free Therapy. Equine Asthma.

RESUMO

A asma equina é uma enfermidade respiratória crônica, sem cura conhecida e, se não for adequadamente tratada, pode se agravar com o tempo e grau de exposição a alérgenos e patógenos. Ela é caracterizada por broncoconstrição e hipersecreção de muco, resultando em dificuldade respiratória e podendo levar a um remodelamento pulmonar. Atualmente é classificada em asma leve a moderada (mEA) e asma grave (sEA), a depender da manifestação clínica apresentada. O tratamento convencional envolve o uso de antiinflamatórios corticosteróides, broncodilatadores e manejo. Embora os tratamentos sejam abrangentes e eficientes, controlam apenas os sinais clínicos e não controlam a inflamação por longos períodos, pois são sempre dependentes de medicamentos, cuidados nutricionais e ambientais. A medicina regenerativa, no entanto, pode ter efeitos mais prolongados sobre o processo inflamatório e sobre o remodelamento pulmonar, visando a reparação e a regeneração teciduais. Entre as terapias disponíveis destacam-se as acelulares, como plasma rico em plaquetas (PRP), alfa-2-macroglobulina (A2M), proteína antagonista do receptor de interleucina-1 (IRAP) e proloterapia, além das terapias celulares baseadas em células-tronco mesenquimais (CTMs). As terapias celulares são capazes de estimular a liberação de um conjunto de moléculas bioativas, os secretomas, compostos por citocinas, fatores de crescimento, proteínas, exossomos e vesículas extracelulares. Esses produtos apresentam propriedades imunomoduladoras, anti-inflamatórias e regenerativas, favorecendo a redução do estresse oxidativo, da apoptose celular e da inflamação pulmonar. Já as terapias livres de células podem apresentar os mesmos efeitos imunomoduladores, mas apresentam vantagens como maior facilidade de armazenamento, menor risco imunológico e maior padronização em comparação ao uso direto das células. Estudos em equinos demonstram que a administração intratraqueal de células mononucleares da medula óssea e de CTMs derivadas do tecido adiposo reduz a inflamação pulmonar, atenua os sinais clínicos e modula a produção de citocinas inflamatórias. Apesar dos resultados promissores, persistem desafios relacionados à padronização dos protocolos, caracterização celular, definição de doses, vias de administração e regulamentação específica. Assim, a medicina regenerativa representa uma alternativa terapêutica inovadora e promissora para a asma equina, embora sua consolidação clínica dependa de novos estudos que comprovem sua segurança, eficácia e reprodutibilidade.

Palavras-chave: Medicina Regenerativa. Terapia Celular. Terapia Livre de Células. Asma Equina.

RESUMEN

El asma equina es una enfermedad respiratoria crónica, sin cura conocida y, si no se trata adecuadamente, puede agravarse con el tiempo y el grado de exposición a alérgenos y patógenos. Se caracteriza por broncoconstricción e hipersecreción de moco, lo que resulta en dificultad respiratoria y puede llevar a un remodelamiento pulmonar. Actualmente se clasifica en asma leve a moderada (mEA) y asma grave (sEA), según la manifestación clínica presentada. El tratamiento convencional implica el uso de antiinflamatorios corticosteroides, broncodilatadores y manejo. Aunque los tratamientos son amplios y eficientes, solo controlan los signos clínicos y no controlan la inflamación por largos períodos, pues siempre dependen de medicamentos, cuidados nutricionales y ambientales. La medicina regenerativa, sin embargo, puede tener efectos más prolongados sobre el proceso inflamatorio y sobre el remodelamiento pulmonar, con el objetivo de la reparación y regeneración tisular. Entre las terapias disponibles se destacan las acelulares, como el plasma rico en plaquetas (PRP), la alfa-2-macroglobulina (A2M), la proteína antagonista del receptor de interleucina-1 (IRAP) y la proloterapia, además de las terapias celulares basadas en células madre mesenquimales.

(CMM). Las terapias celulares son capaces de estimular la liberación de un conjunto de moléculas bioactivas, los secretomas, compuestos por citocinas, factores de crecimiento, proteínas, exosomas y vesículas extracelulares. Estos productos presentan propiedades inmunomoduladoras, antiinflamatorias y regenerativas, favoreciendo la reducción del estrés oxidativo, de la apoptosis celular y de la inflamación pulmonar. Por su parte, las terapias libres de células pueden presentar los mismos efectos inmunomoduladores, pero ofrecen ventajas como mayor facilidad de almacenamiento, menor riesgo inmunológico y mayor estandarización en comparación con el uso directo de las células. Estudios en equinos demuestran que la administración intratraqueal de células mononucleares de la médula ósea y de CMM derivadas del tejido adiposo reduce la inflamación pulmonar, atenúa los signos clínicos y modula la producción de citocinas inflamatorias. A pesar de los resultados prometedores, persisten desafíos relacionados con la estandarización de los protocolos, la caracterización celular, la definición de dosis, las vías de administración y la regulación específica. Así, la medicina regenerativa representa una alternativa terapéutica innovadora y prometedora para el asma equina, aunque su consolidación clínica depende de nuevos estudios que comprueben su seguridad, eficacia y reproducibilidad.

Palabras clave: Medicina Regenerativa. Terapia Celular. Terapia Libre de Células. Asma Equina.

1 EQUINE ASTHMA

Asthma is a chronic and multifactorial respiratory disease, characterised by recurrent episodes of respiratory distress, resulting from bronchoconstriction, mucus hypersecretion, inflammatory infiltrate and remodelling of the pulmonary tissue. It can naturally affect horses, cats and humans, and can be artificially induced in other species, including dogs, sheep and rodents (Woodrow *et al.*, 2023).

It may manifest in the mild/moderate (mild/moderate asthma; mEA) or severe (severe equine asthma; sEA) forms, with subtle clinical signs, such as exercise intolerance, up to quite evident signs, such as coughing, nasal discharge and dyspnoea, presented intermittently with episodes lasting from days to months (Mańkowska & Witkowska, 2024). In horses, the described prevalence is from 14% to 80% (Ivester *et al.*, 2018), with the severe form of the disease potentially affecting 20% of horses over 7 years of age (Couetil *et al.*, 2020).

Chronic bronchitis or bronchiolitis were once terms used for the disease and, in the foreign literature, the term 'heaves', or 'chronic obstructive pulmonary disease – COPD', can also be found, the latter no longer being used since the International Workshop on Equine Chronic Airway Disease that took place at the University of Michigan in the year 2000 (Kinnison 2022). At that event, researchers in the field understood that COPD was a disease related to humans, characterised by chronic irreversible airway alterations, usually related to cigarette use (Wu *et al.*, 2024), which did not correspond to the equivalent condition in horses. Two new designations were proposed: Inflammatory Airway Disease (IAD), which affects horses of any age, especially of working age and younger, and Recurrent Airway Obstruction (RAO) for the more severe condition where recurrent episodes of respiratory distress are observed at rest. Over the last 10 years, IAD and RAO have been encompassed as different stages or presentations of the same disease, Equine Asthma (EA), or Equine Asthma Syndrome, given the clinical and pathological similarities between the disease in horses and in humans. Currently, the terms mild to moderate asthma – mEA or severe asthma – sEA are used, as mentioned previously (Kinnison 2022). Now, beyond the phenotypes of asthma, we are moving towards a classification of endotypes, which is used to describe a subtype of the disease involving its molecular mechanisms, genetic variations or response to treatment (Couetil *et al.*, 2020).

Both the diagnosis and the treatment of equine asthma constitute challenges for the clinician. The former involves a thorough physical examination with a detailed history of the patient, followed by complementary endoscopic examinations and cytology of airway secretion samples, whether from a tracheal wash or a bronchoalveolar lavage. Once the

diagnosis is confirmed, an appropriate therapeutic plan can be devised, for the control of the clinical signs of respiratory distress and for the control of inflammation. In the severe form of the disease, bronchodilators are employed. In both forms of asthma, the control of inflammation is fundamental, since it is the inflammatory response that leads to the increased production of mucus observed in the trachea and bronchi, and that obstructs the small airways, interfering with gas exchange; the chronic inflammatory process is responsible for the pulmonary tissue alterations that worsen with age. In this sense, corticosteroids have been the mainstay for the control of chronic pulmonary inflammation, but their use is indicated for the control of the disease and cannot be maintained over long periods. Acetylcysteine, omega-3 fatty acids, immunostimulants and acupuncture may be associated. In any case, the control of the disease must necessarily be accompanied by environmental improvements regarding ventilation, hygiene and reduction of dust from the bedding, the workplace and especially the hay.

2 REGENERATIVE THERAPIES AND EQUINE VETERINARY MEDICINE

Regenerative Medicine (RM) is a generic term that has been used to encompass several therapies, among which are cell-based therapies, which include the use of stem cells, and the non-cellular ones, which include: prolotherapy, platelet-rich plasma (PRP) therapy, alpha-2-macroglobulin (A2M), interleukin-1 receptor antagonist protein (IRAP) and stem cell therapy (DeChellis e Cortazzo 2011).

Prolotherapy can be summarised as the stimulation of tissue repair through the injection of substances into wounds, tendons and joints for the recovery of an injury or the attenuation of pain (Fullerton e Reeves, 2010). Several agents are used in prolotherapy, some classified as irritants (phenol), chemotactics (sodium morrhuate) and others as osmotic agents (dextrose) (Siadat & Isseroff, 2019).

PRP is a component of plasma with 3 to 7 times more platelets than whole blood and contains growth factors, histamine, serotonin, calcium, zinc, superoxide dismutase (SOD) and adenosine triphosphate (ATP), being employed in several areas, from mammalian reproduction to dermatology and orthopaedics (Sajjad *et al.*, 2024). PRP acts on healing and tissue repair, since, in addition to growth factors, it contains cytokines, which are essential for wound healing (Brissett e Hom, 2003). However, its composition may vary significantly, depending on the donor individual, the form of collection and the processing of the material (Perinelli *et al.*, 2020; Serteyn *et al.*, 2026).

Therapies based on alpha-2-macroglobulin (A2M) and on interleukin-1 receptor antagonist protein (IRAP) have been proposed for osteopathies, joint diseases and

tendon/ligament injuries to prevent degrading effects after injuries, since, like PRP, they have growth factors and a diversity of interleukins in their compositions, promoting a reparative and immunomodulatory effect (Barot *et al.*, 2025).

The efficacy of autologous blood-derived products is directly related to the profile and quantity of cytokines and growth factors released by the platelets and leucocytes. Some of these compounds are commercially available, including platelet-rich plasma (PRP; Restigen; Zoetis), autologous protein solution (APS; Pro-Stride; Zoetis) and autologous conditioned plasma (ACP; Arthrex ACP) and, more recently, conditioned A2M (CA2M; Alpha2EQ; Astaria Global) (Barot *et al.*, 2025).

While the previous therapies have their main focus on tissue repair, stem cell therapy has its focus on tissue regeneration (Fortier e Smith, 2008; Krafts 2010; SerTEYN *et al.*, 2026), having an application of several cell types and their products, employed in different ailments (Voga *et al.*, 2020).

3 CELL-FREE THERAPIES

3.1 PLATELET-RICH PLASMA – PRP

Autologous platelet-rich plasma (PRP) is a processed liquid fraction of autologous peripheral blood, with a platelet concentration above that found in baseline measurements (Marx, 2001). Therapies with PRP have been employed for more than 30 years in regenerative medicine (Everts *et al.*, 2020) and veterinary medicine (Tambella *et al.*, 2018).

PRP preparations have been employed in equine medicine especially for musculoskeletal problems. In the study by Maia *et al.* (2009), PRP was applied to injuries of the superficial digital flexor tendon; for this, blood was collected in tubes containing sodium citrate, and underwent a double centrifugation process, the first at 120g for 5 minutes and the second at 473g for 5 minutes.

The use of PRP in the airways is described especially for healing in surgical procedures, such as that proposed for laryngotracheal reconstruction in a model with laboratory animals (Onder *et al.*, 2020).

The use applied to pulmonary treatment was initially suggested by Dzyekanski *et al.* (2012), proposing that the anti-inflammatory effects inherent to PRP would benefit horses with mild to moderate asthma, previously known as inflammatory airway disease (IAD). In that study, 10 horses attended in routine practice were investigated, as they were presenting coughing. The animals underwent a thorough physical examination, followed by endoscopic evaluation of the airways, and cytological evaluation of the bronchoalveolar lavage fluid (BALF). The PRP was obtained from peripheral blood collected from the jugular vein and

placed in tubes containing citrate phosphate dextrose adenine (CPDA) anticoagulant solution, and processing by double centrifugation at 210g for 10 minutes followed by 300g for 10 minutes, at room temperature. In a procedure guided by endoscopy, 20 ml of PRP suspension were instilled in the region of the tracheal bifurcation, directed to the right and left main bronchi. The study showed positive effects of PRP in the horses that were identified with pulmonary inflammation related to mEA, but not in those with severe asthma. Additionally, it left the suggestion that the use of PRP could also benefit horses with exercise-induced pulmonary haemorrhage (EIPH), through the decrease in the percentage number of haemosiderophages in the BALF at the re-evaluation seven days after treatment.

Recently, Pires *et al.* (2021) employed PRP instilled by the tracheal route in 37 Thoroughbred racehorses diagnosed with EIPH. In that study, PRP was obtained using the double centrifugation technique at 120g and 240g for 10 minutes each, and 10 ml of the PRP suspension was instilled in the region of the tracheal bifurcation. All horses were evaluated by means of endoscopic examination of the airways within 60 minutes after racing, and cytology of the tracheal wash performed 72 hours afterwards; concomitantly with the PRP treatment, furosemide was administered according to its own regulation, and again the previous procedures, endoscopy after a second race (between 3 and 5 weeks after the PRP instillation) and cytology of the tracheal wash, at the same times. The addition of PRP treatment to the furosemide injection proved beneficial, reducing the intensity of EIPH in 26% of the cases.

The two studies using PRP evidenced promising effects, but with important limitations in both, such as a reduced number of animals, variables influencing the observed results, non-constant re-evaluation periods, uncontrolled exercise intensity — in short, requiring further research with better control of the variables involved.

4 CELLULAR PRODUCTS

In recent years, mesenchymal stem cells (MSCs) have been highlighted for their capacity to secrete various bioactive molecules into the surrounding environment, and this product came to be called conditioned medium, secretome or cell-free therapy. In this sense, in diseases that involve an inflammatory infiltrate, as in equine asthma, the importance of the secretion of immunomodulatory factors is mentioned, also called the paracrine effect of MSCs (Barussi *et al.*, 2016).

The secretome of MSCs may contain cytokines, chemokines, cell adhesion molecules, lipid mediators, interleukins, growth factors, hormones, proteins, exosomes, microvesicles and extracellular vesicles. These factors were considered protagonists in tissue repair and

regeneration through their paracrine actions that mediate cell-to-cell signalling (Cai *et al.*, 2020; Kumar *et al.* 2019).

The use of cell-free therapies may generate as a response cell proliferation, migration and angiogenesis; suppression of cell apoptosis and inflammation; tissue regeneration; reduction of oxidative stress and immune regulation (Cai *et al.*, 2020; Kumar *et al.* 2019).

In addition to the responses that this type of therapy may generate, the secretome presents some advantages compared with the use of MSCs. Its obtention can be carried out in larger quantities, reducing the variability between donors; it has greater ease of transport and storage; it can be safely used in allogeneic transplants and it eliminates the risk of clot formation (Cai *et al.*, 2020; Cargnoni *et al.*, 2012). It is currently understood that MSCs need to be activated by pro-inflammatory cytokines present in the microenvironment in order to exhibit their immunomodulatory effects (Del Fattore *et al.*, 2015). In this sense, as they are not living cells, but rather cellular products that transport specific paracrine signals, the immunomodulatory effects of the secretome may be expected to be less dependent on the microenvironment and, therefore, more predictable. Thus, they circumvent major obstacles of the clinical use of MSCs: the need for procedures to harvest autologous cells and the cultivation time until application (Kay *et al.*, 2017).

However, one concern regarding the published studies is the standardisation of the cultivation conditions. Lately, in order to avoid the risk of immunological reactions and to eliminate the transmission of zoonotic diseases due to the use of foetal bovine serum (FBS), MSCs are increasingly being propagated in xenogeneic-free medium; thus, it is not clear whether the data obtained in clinical trials based on MSCs cultivated with FBS would be comparable to the data obtained with MSCs cultivated in xenogeneic-free medium. Furthermore, MSCs differ significantly in their gene expression patterns and, not unexpectedly, also demonstrate heterogeneity in the secretome profile, with the differences attributable to the source of the cells and the age of the donor (Kumar *et al.*, 2019).

Nevertheless, this approach, especially in the veterinary sphere, is still in its early stages. Only recently has the therapeutic use of the MSC secretome, instead of the parental cells, been proposed for veterinary applications. In the equine clinic, one study has already described the use of conditioned medium in ligament and tendon injuries with favourable results (Lange-Consiglio *et al.*, 2013). However, other studies continue to be published only with *in vitro* approaches (Bastos *et al.*, 2020; Mocchi *et al.*, 2021) and, so far, no research has been directed towards the use in respiratory conditions.

5 CELL-BASED THERAPIES

It is interesting to point out that, although there is regulation and careful recommendations made by the Conselho Federal de Medicina Veterinária – CFMV for the use of cell therapy in animals, there are no specific bodies and regulations regarding the standardisation and/or recommendations of quantities/doses, cell types, and especially quality control of the biological material used in veterinary medicine. Some animal species (dogs, cats, horses and rabbits) can be extremely important as preclinical models of human diseases, and, in some cases, serve this purpose better than commonly used laboratory animals (Fortier e Travis, 2011).

In human medicine, there are bodies that oversee and regulate the use of cell therapy, such as the Food and Drug Administration (FDA) in the United States and the Ministério da Saúde/Agência Nacional de Vigilância Sanitária (ANVISA) in Brazil, whereas in veterinary medicine there is no such care. Thus, veterinarians may offer 'cell therapies' using stem cells of various origins as well as in varying doses for several species without concrete evidence of the efficacy of many of these procedures (Fortier, L. A., e Travis, A. J. 2011).

When we speak of cell-based therapies, we have two spheres: one is that of non-cultured or non-expanded cells, and the other is that of cultured and expanded cells and their cellular products. Therapies made from non-expanded cells have a heterogeneity of cell populations, a rapid processing time, facilitating the treatment of acute injuries and reducing costs, with almost exclusively autologous use, with a pool of HSCs and MSCs, possessing haematopoietic, angiogenic and immunomodulatory properties (Borjesson e Peroni 2011). Therapies made from expanded cells, on the other hand, have a large quantity of MSCs, are well known for their immunomodulatory capacities, and can be applied in an autologous, allogeneic or xenogeneic manner; however, the expansion of MSCs can take weeks, thus preventing the immediate use of these cells (Lin *et al.*, 2012). In addition to the high number of MSCs, another advantage of expanded cultures is the addition of other compounds that can potentiate the therapy (Borjesson e Peroni 2011).

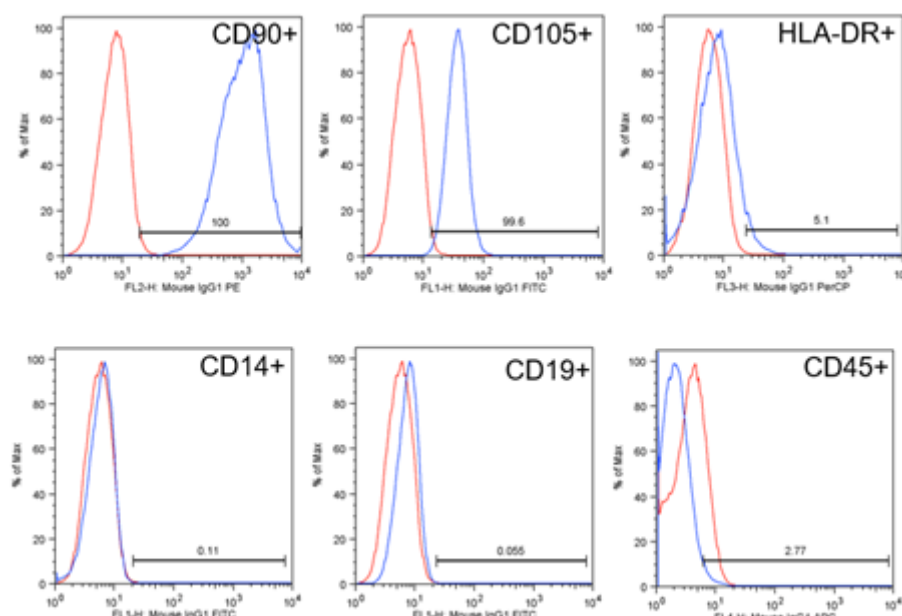
The International Society for Cellular Therapy (ISCT) has three minimum criteria to define a population of human MSCs: adherence to plastic; differentiation into adipogenic, chondrogenic and osteogenic lineages; high expression of the surface markers CD73, CD90 and CD105 (above 95%), and low expression of CD34, CD45, CD14 or CD11b, MHC-II and CD19 or CD79 α (below 2%). However, according to Dominici *et al.* (2006), the expression of surface antigens is not universally well characterised and the recommended antigens may not apply to other species. For equine MSCs, the difficulty in characterising the cells is observed due to the limited availability of species-specific monoclonal antibodies (mAb), as

demonstrated by the study of De Schauwer *et al.* (2012), in which the cross-reactivity of 30 commercial mAbs for the recognition of equine epitopes was studied. As a result, only 11 antibodies presented satisfactory results.

The study by Bastos *et al.* (2020) carried out the immunophenotypic characterisation of equine bone marrow MSCs by flow cytometry, using the following mAbs (Figure 1): anti-human CD90, anti-human CD19, anti-human CD14, anti-horse CD105, anti-horse CD45 and anti-human HLA-DR (Dominici *et al.*, 2006). The panel was assembled after a pilot assay, in which the labelling of mononuclear cells and mesenchymal cells with several available antibodies was carried out. After the pilot, CD73, CD166 and CD29 were excluded from the study for not presenting the expected reactivity. The anti-human mAbs CD45 and CD105 also did not present the expected reactivity, but other clones were found that presented cross-reactivity with the horse.

Figure 1

Immunophenotypic characterisation of equine bone marrow mesenchymal stromal cells, evaluated by flow cytometry. Representative histograms of one sample from the study, analysed at the third passage. The peaks in blue indicate the percentage of the population positive for each antibody, while the peaks in red indicate the isotype control of the antibodies. CD90 and CD105 proved positive, while HLA-DR, CD14, CD19 and CD45 proved negative (low expression). CD = clusters of cell differentiation; HLA = human leucocyte antigen



Source: prepared by the authors.

In the literature, the labelling for CD90 in equine cells was carried out with several different mAbs, also obtaining different results. Expressions above 90% were obtained for

equine MSCs with anti-human CD90 (100%, Bastos *et al.*, 2020; 96%, Cabezas *et al.*, 2018; 90%, Ranera *et al.*, 2011), anti-rat (98.2%, Barberini *et al.*, 2014) and anti-dog (91.34%, Carrade *et al.*, 2012).

Regarding the CD45 marker, there are results close to that recommended by the ISCT, with labelling below 2%, using anti-human antibodies (Ranera *et al.*, 2011; Paebst *et al.*, 2014) or anti-mouse (Cabezas *et al.*, 2018). In the study by Bastos *et al.* (2020), using an anti-horse antibody, the CD45 marker was above the limit recommended by the ISCT, but below 10%, which is the limit used in laboratories licensed by ANVISA.

The CD105 marker is the one that presents the greatest discrepancy in the results already published for equine MSCs. Using anti-human antibodies, the work of Ranera *et al.* (2011) obtained no reading for CD105, Paebst *et al.* (2014) obtained results below 0.85% and Cabezas *et al.* (2018) obtained an average of 23.86%. Higher expressions were obtained in the work of Xie *et al.* (2013), with an average of 64%, but still outside what is recommended by both the ISCT and ANVISA (95% and 70%, respectively). Only the article by Barberini *et al.* (2014) demonstrated expressions above 95% (average of 97.7%). The study by Bastos *et al.* (2020), in turn, used CD105 with reactivity for the horse and achieved readings above 95% in all the samples analysed.

Only the studies of Paebst *et al.* (2014) and Bastos *et al.* (2020) labelled equine MSCs with CD14. The results were below 2%, as expected, even with the use of different clones (clone 134620 vs. M5E2, respectively).

The negative markers CD19 and HLA-DR were only described in the work of Bastos *et al.* (2020). CD19 presented consistent results below 2%. HLA-DR, in turn, had considerable variability in the readings, but all were below 10%. The results for the negative markers must be interpreted with caution, since, due to the absence of species-specific mAbs, the low expression may be a result of the absence of cross-reactivity (Ranera *et al.*, 2011). In this sense, the labelling of mononuclear cells as a control is of great importance.

5.1 AUTOLOGOUS VS. ALLOGENEIC VS. XENOGENEIC

To choose the best cell therapy to be employed in a given pathology, it is necessary to weigh some factors such as: the most indicated cell type, the most indicated modality (autologous vs. allogeneic vs. xenogeneic), the cost of the therapy, the possibility of collection for autologous use, the existence of donors for the allogeneic and xenogeneic modalities, an adequate facility for processing the cellular material, a trained team for the application of the therapy and for follow-up of the patient.

Among the arguments that justify the choice of using autologous or allogeneic therapies, which are the most commonly used and the most indicated in veterinary medicine, at least so far, are that: the use of allogeneic MSCs includes a greater risk of immunological reactions and shorter cell survival times after injection; while the use of allogeneic MSCs includes the capacity to store cells, reduce treatment time and collect MSCs from younger and healthier donor animals (Colbath *et al.*, 2020).

While the use of autologous and allogeneic stem cells is increasingly established, the use of xenogeneic cells is still controversial. In a study carried out with autologous, allogeneic and xenogeneic bone marrow-derived mesenchymal stem cells (BMMSCs), applied intra-articularly in horses, it was concluded that there was an immune response in joint samples, collected by synovial biopsies obtained by arthroscopy 60 days after treatment (macroscopic, histological and molecular analyses) after the re-exposure of the group to xenogeneic MSCs, but not to allogeneic or autologous MSCs (Pigott, *et al.*, 2013).

Even though it is commonly employed, the use of allogeneic MSCs still draws attention, since some studies report evidence of inflammatory reactions or adverse clinical responses when allogeneic MSCs are administered and compared with autologous MSCs (Joswig *et al.*, 2017; Van Hecke *et al.* 2021). In this whole scenario, a small detail can make a big difference: the type of vehicle to carry the MSCs. In the study by Van Hecke and collaborators (2021), significant alterations were detected in the use of allogeneic intra-articular cell therapy that used allogeneic plasma in its composition, which prompts questions about the differences between autologous versus allogeneic therapies.

Even though they are commonly employed, the use of allogeneic MSCs still draws attention, being continuously studied, since each methodology employed brings peculiarities and distinct, sometimes divergent, results (Joswig *et al.*, 2017; Van Hecke *et al.* 2021).

The safe use of allogeneic MSCs was described in humans and horses (Carrade *et al.*, 2011a; Carrade *et al.*, 2011b; Fang *et al.*, 2007). When using allogeneic MSCs, we have the opportunity to select high-quality MSCs and perform viral and bacteriological examinations at the time when the stem cell samples are frozen. Since MSCs are present in a limited way (in number in natural sources), *in vitro* expansion is necessary, taking from weeks to months, requiring a programmed application, demanding preservation and making applications immediately after the collection of the material unfeasible (Gugjoo *et al.* 2016; Perez-Silos *et al.* 2016).

6 COLLECTION AND PROCESSING OF CELLULAR MATERIAL

Before beginning this subject, it is relevant to say that there are recommended techniques for each type of collection and material to be used, but there are also variations of them that can and should be taken into consideration, depending on the conditions of the patient, the therapy, the costs or the objectives of the research.

The choices must also be based on the type of stem cell that one intends to work with, since different types of stem cells can lead to different results. Among the types of cells are: haematopoietic stem cells (HSCs), embryonic stem cells (ESCs), mesenchymal stem cells (MSCs) and induced pluripotent stem cells (iPS). The types of cells differ in their capacity for replication and differentiation, tissue of origin and therapeutic indications (Borjesson e Peroni 2011).

As for costs, it can be said that the more time, structure, labour and storage time the stem cells demand, the higher the costs become. In addition to cells, cellular products are used in regenerative veterinary medicine; thus, there is a growing search for the improvement of techniques and compounds that aim to increase productivity and its flexibility (Bradley *et al.*, 2010).

The collection process begins with the donation of tissues coming from veterinary or human hospitals (in the case of xenogeneic cells) or from veterinarians who carry out collections in animals of their routine (necessarily with the written consent of the owners); it is also necessary for everything to be approved by an animal use ethics committee. The cells are then sent to companies or teaching and research institutions, where, in specialised laboratories, they will be processed, stored and prepared for application.

6.1 PERIPHERAL BLOOD

The choice of peripheral blood as a source of stem cells may be related to the low cost and the ease of obtaining the blood tissue. Although this obtention is relatively easy and cheap, the stem cells contained in this tissue are present in smaller quantities when compared with other sources (bone marrow, adipose tissue and umbilical cord); this requires the cells to undergo cultivation, where they will be expanded and subsequently characterised.

Peripheral blood is a source of mononuclear cells (MNCs) that possess HSCs, capable of differentiating into all types of blood cells, and MSCs, capable of differentiating into three lineages: bone, cartilage and adipose (Dhar *et al.*, 2021). In clinical routine, the most used are the MSCs, indicated for the treatment of tendons, ligaments, bone pathologies and cartilage defects (Martinello *et al.*, 2009; Spaas *et al.*, 2011).

Equine blood is commonly collected by venepuncture of the jugular into anticoagulant (usually Heparin) and then sedimented or centrifuged, and from there the sample is processed according to the fraction of cells that one wishes to obtain (Dhar *et al.*, 2021; Koerner *et al.*, 2006; Martinello *et al.*, 2009; Spaas *et al.*, 2011).

6.2 BONE MARROW

Bone marrow (BM), in equine veterinary medicine, is used both for the obtention of MNCs (without cultivation) and MSCs (after cultivation). The volume of marrow to be collected depends on the type and quantity of cells to be applied. While the dose of MSCs employed intra-articularly in osteoarticular injuries is around 10×10^6 cells (Bertoni *et al.* 2021; Joswig *et al.* 2017), the dose of MNCs applied intratracheally in horses with severe asthma was between 5 and 10×10^8 cells (Barussi *et al.*, 2019). Thus, the volume of BM obtained in a single collection usually varies from 5 to 30 mL per horse (Bastos *et al.* 2017); however, Barussi and collaborators (2016) collected 200 mL of BM, justified by the need for a large volume of MNCs for autologous transplant. As the therapy required a large volume of BM, the source chosen was the sternum. The iliac crest was also tested as a source of BM, but the difficulty of obtaining material was much greater, leading the group to conclude that this site, although easily accessible, is more indicated for small quantities.

The horses were kept fasting for at least six hours before the procedure, for sedation with 1% acepromazine intravenously (IV). The collection site between the fourth and sixth sternbrae was clipped, followed by local subcutaneous anaesthesia with 8 mL of 2% lidocaine hydrochloride and antisepsis with degerming povidone-iodine and alcohol. Afterwards, the sedation was complemented with 10% xylazine IV and 5% pethidine hydrochloride IV.

For the puncture, an 11G Jamshidi needle for BM biopsy and collection and 20 mL syringes previously filled with 7 mL of Iscove's Modified Dulbecco's Medium (IMDM) and 0.35 mL of sodium heparin 5000 IU/mL were used. Once collected, the BM was taken to the laboratory under refrigeration, where the mononuclear fraction was isolated by density gradient and subsequently cryopreserved at -192°C .

6.3 ADIPOSE TISSUE

The removal of adipose tissue (AT) is usually carried out in the region above the dorsal gluteal muscle near the base of the tail, since it is easily accessible, is not supplied by large vessels and has great availability of material (Carvalho *et al.* 2009). The animals are kept

under sedation and receive local anaesthesia in an inverted 'L' shape using 2% lidocaine hydrochloride. The AT can be collected by liposuction or surgical procedure.

In cases of liposuction, after clipping, antisepsis and local anaesthesia, the region receives an injection of a fluid composed of sterile 9% NaCl, 2% lidocaine hydrochloride and epinephrine. When the site is uniformly expanded and becomes relatively hyperechoic on ultrasound, the collection proceeds. A minimum of 20 min allows for optimal anaesthesia, haemostasis (via vasoconstriction) and local fluid. Using a sterile technique, the harvest aspiration cannula (Cobra Bibevel) is connected to an empty syringe, ensuring that there is no fluid present to weaken the suction. Once at the site within the adipose layer, the plunger of the syringe is pulled back to create adequate suction pressure. With ultrasound visualisation, the cannula is moved to collect the AT. The same steps for aspiration are then repeated on the contralateral side (J. Lawver and R. Thaler 2015).

In the surgical collection, after clipping, antisepsis and local anaesthesia, the region is accessed by a small incision between 10 and 15 cm in length, allowing the visualisation of the AT between the skin and the musculature. A sample of AT is removed, placing it immersed in culture medium until it is processed. The skin is sutured with nylon thread in simple interrupted stitches.

6.4 FOETAL ADNEXA

The material collected from foetal adnexa may involve umbilical cord blood, Wharton's jelly (umbilical cord tissue), the placenta and the amniotic fluid. Among this range of materials, there are different types of processing, but all of them involve cell isolation and cultivation, significantly impacting the difference in costs and results (Iacono *et al.*, 2012). In a study carried out by Bertoni and collaborators (2021), the therapeutic efficiency of the use of bone marrow-derived stem cells was greater than those derived from umbilical cord.

The amniotic fluid is collected, purified (to eliminate urinary residues and crystals), the cells are isolated and then taken to cultivation. The umbilical cord blood must be collected quickly, since after birth there is a collapse of the umbilical vein. The cells are isolated, washed several times to eliminate other cell types (non-adherent) and taken to cultivation. As the birth canal, as well as the environment, are non-sterile conditions, this represents a great risk of contamination, and it is not difficult to lose samples and cultures as a result of contamination (Iacono *et al.*, 2012).

Although there are studies with foetal adnexa as sources of stem cells, there are no reports of the use of these materials for the treatment of airway diseases in horses, probably because the cost of processing and obtaining the adequate number of cells is a limiting factor.

7 WHEN AND WHY TO OPT FOR CELL THERAPY

Discuss the therapeutic planning (early collection, at a healthy stage), the morphology (which, even cryopreserved, remains stable in BMMC and up to P3 in MSCs); however, discuss cell viability (which decreases over time). It may be worth highlighting the choice of source (adipose tissue, bone marrow or peripheral blood) based on a possible response profile (neovascularisation, tissue formation or immunomodulation).

Table 1

Triage of cell therapy according to clinical urgency, examples and indicated therapy

TRIAGE	EXAMPLES	INDICATED THERAPY
URGENT THERAPY	Corneal ulcer, deep wounds, exercise-induced pulmonary haemorrhage, ligament and tendon diseases.	Cryopreserved autologous BMMC or MSC, fresh BMMC, allogeneic or xenogeneic MSC.
LITTLE-URGENT THERAPY	Equine metabolic syndrome, asthma, wounds with difficult healing, exercise-induced pulmonary haemorrhage, ligament and tendon diseases.	Fresh or cryopreserved autologous BMMC or MSC, allogeneic MSC.
NON-URGENT THERAPY	Asthma, muscular, ligament and tendon diseases.	Fresh or cryopreserved autologous BMMC or MSC, allogeneic MSC.

Source: prepared by the authors.

7.1 PROFILE OF THE PATIENT INDICATED FOR CELL THERAPY

Cell-based therapies represent a possible therapeutic option for many diseases in veterinary medicine, including neoplasms, orthopaedic, digestive, hepatic, renal, cardiac, respiratory, neuromuscular, dermal, olfactory and reproductive system diseases. Although we are progressively understanding the behaviour of stem cells and their mechanisms of action, some of the questions regarding their use are in constant refinement.

There is also a possible influence of age and sex on the results of cell therapy, which should be clarified in future studies.

And the equation of type of disease x therapeutic indications x dosage – number of cells and frequency of application x condition of the patient is what makes the veterinarian consider or not cell therapy as a viable alternative.

- a) TYPE OF DISEASE – determine whether the disease presented by the patient has a profile indicated to receive cell therapy.

- b) THERAPEUTIC INDICATIONS – know whether there are no traditionally known methods that can be applied and offer good recovery rates to the patient. In the case of an indication for the use of cell therapy, know which would be the most indicated types.
- c) DOSAGE – according to the type of disease and therapeutic indications, carry out a survey of the most used practices regarding the number of cells, forms (injected, instilled, inhaled, etc.) and repetitions of the applications.
- d) CONDITION OF THE PATIENT – understand the condition of the patient to know whether it has the conditions to be its own donor (autologous therapies), whether another donor of the same species should be an alternative (allogeneic transplants) or even a donor of another species (xenogeneic transplant). This understanding includes taking into account the age of the patient, the general state of health, and the exposure to a possible collection and transplant procedure.

In general, cell transplants involve simple procedures, with sedation and local anaesthesia. However, they require knowledge and expertise from the veterinarian, demanding knowledge and good practices in their performance. Thus, there are no major restrictions on the application of cell therapy in horses, especially if the modality is allogeneic transplant. The greatest restrictions are for elderly and ill patients, who already have debilitated health (especially due to degenerative, progressive diseases with no established cure), since the effects of these diseases on the patients' immune system and their cellular response are unknown, an alert for autologous transplants.

8 RESULTS

8.1 IN ASTHMA

Asthma is an inflammatory disease, with no cure so far, that can cause severe limitations and irreversible damage to those affected. Regenerative medicine brings the expectation of tissue repair and regeneration, having important weight in the prognosis and longevity of the patient.

Eight horses with sEA were treated with a single intratracheal dose of bone marrow mononuclear cells (BMMC), presenting a decrease in respiratory effort and clinical score. The percentage of neutrophils decreased and that of macrophages increased in the BALF, as well as the levels of IL-10, when compared with the group treated with dexamethasone. The quantification of IL-4, IL-17, IFN- γ and IFN- α showed no alterations between the evaluations in both groups. These results suggest that the cell therapy adopted attenuated the inflammatory response of sEA (Barussi *et al.*, 2016).

The intrabronchial administration of adipose tissue-derived mesenchymal stromal stem cells (AT-MSC) significantly improved the clinical score, reduced the expression of IL-17 and the protein levels of IL-1 β , IL-4 and TNF α ($P = 0.02$) in asthmatic horses, having anti-inflammatory effects in the short term, and reduced the clinical signs of sEA after one year (Adamic *et al.*, 2022).

Recently, some horses received cellular products, derived from mesenchymal cell supernatants. This by-product was administered by the inhalation route, with the objective of evaluating both the therapeutic potential and the form of administration. The researchers concluded that the inhalation of the MSC supernatant presents itself as a potential therapeutic route for equine asthma, although efficacy trials are necessary, in addition to highlighting the potential of this approach in a possible management of human asthma (Colabufalo *et al.*, 2025).

Although the results are promising, further studies are necessary on the application of cells and derived products in airway diseases in horses, since it is a vast field and presents obstacles that need to be overcome until well-established therapies become consolidated.

8.2 ORTHOPAEDIC DISEASES

Cell therapy is more established in diseases of the musculoskeletal system, since it has been worked on for a longer time. It presents some advantages, especially regarding doses and forms of administration. While the dose of MSCs employed intra-articularly in osteoarticular injuries is around 10×10^6 cells (Bertoni *et al.* 2021; Joswig *et al.* 2017), the dose of MNCs applied intratracheally in horses with severe asthma was between 5 and 10×10^8 cells (Barussi *et al.*, 2019).

9 OVERALL OUTLOOK

There are still many variations of cells, cellular products and therapeutic applications, whether in quantity or quality, that may arise from the donor individual, type of sample or originating tissue, collection, processing and storage. There is also diversity regarding safety and quality control, especially when we compare the practices of human medicine and veterinary medicine. Shahid and collaborators (2025) emphasise the importance of the characterisation of the cells before administration, as well as the selection of those most adequate for the specific purpose.

Speaking specifically of equine medicine, in some procedures it is necessary to process or cultivate large volumes of biological material, considerably raising the final cost. One alternative is the use of products available on the market; however, it is important to

remember that they are not autologous. There are also some laboratories that offer the field veterinarian the processing, cultivation and storage of materials, which allows autologous therapy and can be a facilitator.

Among the important points regarding the choice of autologous or allogeneic cells are: the use of allogeneic MSCs includes a greater risk of immunological reactions and shorter cell survival time after injection, while the use of allogeneic ones includes the possibility of storage for long periods, allowing the treatment to be replicated, the collection of cells from young and healthy donors and the capacity to manipulate the stored cells before administration.

It is also fundamental that we understand the indications for use, doses and treatment times, since these conditions directly influence the results. Nevertheless, we had the opportunity to explore several examples that, even with a single use of cellular products and/or derivatives, resulted in important improvement of the condition/patient.

Regenerative medicine has a broad path to be travelled, but undoubtedly a promising one; however, it is necessary to exercise caution and continue seeking scientific foundation, so that the therapy is not prioritised to the detriment of the result.

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INSTITUTIONAL CAPABILITIES FOR ARTIFICIAL INTELLIGENCE GOVERNANCE IN THE PUBLIC SECTOR: EVIDENCE FROM BRAZIL'S MINISTRY OF MANAGEMENT AND INNOVATION IN PUBLIC SERVICES

CAPACIDADES INSTITUCIONAIS PARA GOVERNANÇA DA INTELIGÊNCIA ARTIFICIAL NO SETOR PÚBLICO: EVIDÊNCIAS DO MINISTÉRIO DA GESTÃO E DA INOVAÇÃO EM SERVIÇOS PÚBLICOS

CAPACIDADES INSTITUCIONALES PARA LA GOBERNANZA DE LA INTELIGENCIA ARTIFICIAL EN EL SECTOR PÚBLICO: EVIDENCIAS DEL MINISTERIO DE GESTIÓN E INNOVACIÓN EN LOS SERVICIOS PÚBLICOS



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ABSTRACT

The growing adoption of Artificial Intelligence (AI) in the public sector has intensified challenges related to institutional coordination, risk management, and public value creation. Although the literature has advanced in the development of ethical principles, regulatory frameworks, and governance mechanisms, studies examining how public organisations develop institutional capabilities to govern AI in complex organisational environments remain limited. In this context, this article analyses how such capabilities are developed within Brazil's Ministry of Management and Innovation in Public Services (MGI). The research adopted a qualitative, exploratory, and descriptive approach, based on an instrumental single-case study and document analysis. The findings indicate that AI governance was not structured as an isolated mechanism of technological control but rather integrated into existing practices of digital governance, data governance, and information security. Four central dimensions associated with the development of institutional capability for AI governance were identified: institutional coordination, risk-based oversight, integration between governance and innovation, and continuous organisational adaptation. The results suggest that AI governance can be understood as an institutional capability emerging from the interaction between dynamic capabilities, federated governance, agile bureaucracy, and a public value-oriented approach. The study contributes to advancing the understanding of AI governance in the public sector by shifting the focus from a predominantly normative perspective towards an approach centred on the development of organisational capabilities.

Keywords: Artificial Intelligence. Artificial Intelligence Governance. Dynamic Capabilities. Federated Governance. Public Value.

RESUMO

A crescente adoção da Inteligência Artificial (IA) no setor público tem ampliado os desafios relacionados à coordenação institucional, gestão de riscos e geração de valor público. Embora a literatura avance na formulação de princípios éticos, modelos regulatórios e mecanismos de governança, permanecem limitados os estudos que investigam como organizações públicas desenvolvem capacidades institucionais para governar a IA em ambientes organizacionais complexos. Nesse contexto, este artigo analisa como tais capacidades são construídas no âmbito do Ministério da Gestão e da Inovação em Serviços

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Públicos (MGI). A pesquisa adotou abordagem qualitativa, de natureza exploratória e descritiva, desenvolvida por meio de estudo de caso único instrumental e análise documental. Os resultados indicam que a governança de IA observada não foi estruturada como mecanismo isolado de controle tecnológico, mas integrada às práticas de governança digital, governança de dados e segurança da informação. Foram identificadas quatro dimensões centrais associadas à construção da capacidade institucional de governar IA: coordenação institucional, supervisão baseada em risco, integração entre governança e inovação e adaptação organizacional contínua. Os achados sugerem que a governança da IA pode ser compreendida como uma capacidade institucional resultante da interação entre capacidades dinâmicas, governança federada, burocracia ágil e orientação à geração de valor público. O estudo contribui para ampliar a compreensão da governança de IA no setor público ao deslocar o foco de uma perspectiva predominantemente normativa para uma abordagem centrada na construção de capacidades organizacionais.

Palavras-chave: Inteligência Artificial. Governança de Inteligência Artificial. Capacidades Dinâmicas. Governança Federada. Valor Público.

RESUMEN

La creciente adopción de la Inteligencia Artificial (IA) en el sector público ha ampliado los desafíos relacionados con la coordinación institucional, la gestión de riesgos y la generación de valor público. Aunque la literatura ha avanzado en la formulación de principios éticos, marcos regulatorios y mecanismos de gobernanza, siguen siendo limitados los estudios que investigan cómo las organizaciones públicas desarrollan capacidades institucionales para gobernar la IA en entornos organizacionales complejos. En este contexto, este artículo analiza cómo dichas capacidades son construidas en el ámbito del Ministerio de Gestión e Innovación en los Servicios Públicos (MGI) de Brasil. La investigación adoptó un enfoque cualitativo, de carácter exploratorio y descriptivo, desarrollado mediante un estudio de caso único instrumental y análisis documental. Los resultados indican que la gobernanza de la IA observada no fue estructurada como un mecanismo aislado de control tecnológico, sino integrada a las prácticas de gobernanza digital, gobernanza de datos y seguridad de la información. Se identificaron cuatro dimensiones centrales asociadas a la construcción de la capacidad institucional para gobernar la IA: coordinación institucional, supervisión basada en riesgos, integración entre gobernanza e innovación y adaptación organizacional continua. Los hallazgos sugieren que la gobernanza de la IA puede comprenderse como una capacidad institucional resultante de la interacción entre capacidades dinámicas, gobernanza federada, burocracia ágil y orientación a la generación de valor público. El estudio contribuye a ampliar la comprensión de la gobernanza de la IA en el sector público al desplazar el foco desde una perspectiva predominantemente normativa hacia un enfoque centrado en la construcción de capacidades organizacionales.

Palabras clave: Inteligencia Artificial. Gobernanza de la Inteligencia Artificial. Capacidades Dinámicas. Gobernanza Federada. Valor Público.

1 INTRODUCTION

Artificial Intelligence (AI) has consolidated itself as one of the main technologies driving contemporary digital transformation. In recent years, governments around the world have begun to incorporate systems based on machine learning, natural language processing, and generative models into activities related to public service delivery, data analysis, process automation, and support for public policy formulation (WIRTZ *et al.*, 2020; MERGEL *et al.*, 2019). While expanding the state's capacity to innovate and produce public value, these technologies introduce challenges related to transparency, data protection, accountability, information security, and the management of risks associated with decisions supported by intelligent systems (ZUIDERWIJK *et al.*, 2021; OECD, 2024).

Recent investigations conducted by international bodies, such as the OECD (2024), UNESCO (2024), NIST (2023), and the World Bank (2024), indicate that the central axis of the challenges associated with Artificial Intelligence in the public sector has shifted from mere technological feasibility to institutional complexity. The emerging consensus suggests that the effectiveness of digital transformation increasingly depends on the capacity of public organisations to structure coordination, oversight, and adaptation mechanisms capable of ensuring the responsible use of AI, reconciling innovation, risk management, and the public interest.

Unlike traditional corporate technologies, whose adoption normally occurs through formal processes of planning, procurement, and governance (WEILL; ROSS, 2004), Generative Artificial Intelligence tools present reduced technical and operational barriers to access, enabling their direct use by end users and business areas without the need for specialised development or continuous intermediation by central information technology structures (OECD, 2024; NIST, 2023). The dissemination of generative AI has expanded the need for governance mechanisms capable of reconciling innovation, risk management, transparency, and human oversight, especially in complex organisational contexts (OECD, 2024). This characteristic increases the speed of technological experimentation and favours the emergence of decentralised initiatives, a phenomenon associated with the growth of so-called Shadow AI, in which AI-based solutions are adopted outside the formal mechanisms of organisational oversight (OECD, 2024; JANSSEN; VAN DER VOORT, 2020).

The complexity of this scenario is amplified in public organisations characterised by multiple administrative units, the sharing of technological resources, different levels of decision-making autonomy, and a high diversity of institutional demands. In these situations, excessively centralised mechanisms tend to reduce innovation capacity and generate decision-making bottlenecks, while excessively decentralised approaches may favour

technological fragmentation, duplication of investments, and the loss of strategic alignment (GALBRAITH, 1973; WEILL; ROSS, 2004). The challenge thus becomes one of constructing organisational arrangements capable of balancing autonomy and coordination, innovation and control, flexibility and accountability.

Although the literature on Artificial Intelligence Governance has advanced significantly in recent years, a large part of the research remains concentrated on ethical principles, regulatory aspects, and risk management mechanisms (WIRTZ *et al.*, 2020; ZUIDERWIJK *et al.*, 2021). Studies that empirically investigate how public organisations develop institutional capabilities able to transform these principles into effective practices of coordination, oversight, and organisational adaptation remain relatively scarce. This gap becomes particularly relevant in complex organisational environments, in which the adoption of AI depends on the articulation between multiple actors, governance structures, and distributed decision-making processes.

In view of this context, this article seeks to answer the following research question: which organisational mechanisms contribute to the construction of institutional capabilities able to govern Artificial Intelligence in public environments characterised by high organisational complexity?

To answer this question, the study aims to analyse how dynamic capabilities, federated governance mechanisms, and agile bureaucracy practices are articulated in the construction of the institutional capability to govern Artificial Intelligence in the public sector. Empirically, the investigation uses the experience of the Ministério da Gestão e da Inovação em Serviços Públicos (MGI) as an analytical lens to understand the organisational mechanisms that sustain the coordinated adoption of AI in a context marked by shared services, multiple organisational units, and different levels of decision-making autonomy.

The relevance of the study stems from the growing dissemination of Artificial Intelligence in public organisations and the limited understanding of the organisational mechanisms necessary for its governance. By empirically examining a context characterised by high institutional complexity, the article seeks to contribute to the advancement of the literature on digital governance and the transformation of the State, broadening the understanding of the processes of constructing institutional capabilities for AI governance.

The main theoretical contribution of the study consists of proposing an integrated interpretation of Artificial Intelligence governance in the public sector, understanding it as an institutional capability constructed through the interaction between dynamic capabilities (TEECE, 2007), federated governance (WEILL; ROSS, 2004), and agile bureaucracy mechanisms (MERGEL, 2016; JANSSEN; VAN DER VOORT, 2020). By shifting the

discussion from a predominantly normative perspective towards an approach centred on the construction of organisational capabilities, the study seeks to offer an analytical contribution to the understanding of AI governance in complex public organisations.

In addition to this introduction, the article is structured in six sections. The next section presents the theoretical framework underpinning the analysis. Subsequently, the methodological procedures adopted are described. The fourth section contextualises the case studied. The fifth presents the research results, followed by the discussion of the findings and the proposition of an interpretative model for Artificial Intelligence governance in the public sector. Finally, the conclusions, limitations, and opportunities for future research are presented.

2 THEORETICAL FRAMEWORK

2.1 ARTIFICIAL INTELLIGENCE GOVERNANCE IN THE PUBLIC SECTOR

There is relative consensus in the literature regarding the need for institutional mechanisms designed to ensure transparency, accountability, security, and the management of risks associated with Artificial Intelligence (OECD, 2024; UNESCO, 2024; NIST, 2023). There is also convergence regarding the importance of integrating technological, organisational, and regulatory aspects to enable the responsible adoption of these technologies, especially in public environments characterised by high institutional complexity and multiple decision-making actors (ZUIDERWIJK *et al.*, 2021; WIRTZ *et al.*, 2020).

However, understanding of how these principles are operationalised in complex public organisations remains limited. A large part of the literature concentrates on the formulation of ethical principles, normative guidelines, regulatory models, and conceptual governance frameworks, devoting less attention to the organisational mechanisms necessary to transform such recommendations into effective practices of coordination, oversight, and institutional adaptation (WIRTZ *et al.*, 2020; JANSSEN; VAN DER VOORT, 2020; OECD, 2024).

This gap becomes particularly relevant in view of the dissemination of Generative Artificial Intelligence. Unlike traditional corporate technologies, whose adoption normally occurs through formal processes of planning, procurement, and governance (WEILL; ROSS, 2004), generative tools present reduced technical and operational barriers to access, enabling their direct use by end users and business areas without the need for specialised development or continuous intermediation by central information technology structures (OECD, 2024; NIST, 2023). As a consequence, the need for governance mechanisms capable of reconciling innovation, risk management, transparency, and human oversight is expanded, especially in complex organisational contexts (OECD, 2024). This characteristic

increases the relevance of understanding how public organisations develop institutional capabilities to coordinate the adoption of AI without compromising the creation of public value, regulatory compliance, and the management of risks associated with the technology (MOORE, 1995; BRYSON *et al.*, 2014).

2.2 DIGITAL PUBLIC GOVERNANCE, PUBLIC VALUE, AND ARTIFICIAL INTELLIGENCE

Although the literature presents different perspectives for understanding the creation of public value, there is convergence regarding the need to articulate institutional outcomes, legitimacy, and operational capacity as central elements of public action (MOORE, 1995; BRYSON *et al.*, 2014; OSBORNE, 2021). In parallel, approaches such as the Public Service Logic and the Service-Dominant Logic reinforce the understanding that public value is constructed through the interaction between multiple actors, resources, and capabilities distributed across institutional ecosystems, in which users, organisations, and society jointly participate in value creation processes (VARGO; LUSCH, 2008; OSBORNE, 2021; ECHEVERRI; SKÅLÉN, 2021).

However, the way in which emerging technologies, particularly Artificial Intelligence, simultaneously alter the mechanisms of creation and destruction of public value remains relatively underexplored. Although the literature recognises the potential of AI to expand efficiency, analytical capacity, service quality, and government innovation, it also points to risks related to algorithmic biases, decision-making opacity, discrimination, digital exclusion, and the weakening of public trust (WIRTZ *et al.*, 2020; ZUIDERWIJK *et al.*, 2021; OECD, 2024). Despite these advances, studies that investigate how governance structures can act simultaneously in promoting the benefits and in mitigating the risks associated with the use of AI in the public sector are still limited.

This discussion suggests that the governance of Artificial Intelligence should be analysed not only from a technological or regulatory standpoint, but also as an institutional mechanism designed to enhance the creation and reduce the risks of destruction of public value arising from the inadequate use of these technologies. From this perspective, governance assumes a strategic role in aligning innovation, risk management, institutional legitimacy, and the generation of socially relevant outcomes, contributing to ensuring that the adoption of AI remains consistent with public objectives and democratic principles (MOORE, 1995; BRYSON *et al.*, 2014; OECD, 2024).

2.3 DYNAMIC CAPABILITIES AND THE CONSTRUCTION OF CAPABILITIES TO GOVERN ARTIFICIAL INTELLIGENCE

The literature on dynamic capabilities presents a high degree of consolidation in explaining the processes of organisational adaptation in the face of environments characterised by technological change, uncertainty, and the continuous need for innovation (TEECE; PISANO; SHUEN, 1997; TEECE, 2007; HELFAT *et al.*, 2007). Originally developed in the field of business strategy, this approach has been widely used to understand how organisations develop competences to respond to environmental transformations, reconfigure resources, and sustain their capacity for adaptation over time.

In particular, the dimensions of sensing, seizing, and transforming offer a robust framework for understanding how organisations identify opportunities and threats, mobilise resources, and promote structural changes in the face of new technological and institutional challenges (TEECE, 2007). These capabilities have been progressively incorporated into studies on digital transformation and innovation in the public sector, especially in contexts that demand organisational learning, inter-institutional coordination, and continuous adaptation (JANSSEN; VAN DER VOORT, 2020; MERGEL *et al.*, 2019).

Despite this advance, their application to the context of digital public governance and, more specifically, to the governance of Artificial Intelligence still remains under development. Although recent studies recognise that the adoption of AI requires new organisational capabilities related to risk management, institutional coordination, and technological oversight, investigations that analyse AI governance as a manifestation of the institutional capabilities of organisational adaptation remain limited (WIRTZ *et al.*, 2020; ZUIDERWIJK *et al.*, 2021).

Particularly scarce are studies that examine how public organisations develop permanent competences to identify technological opportunities, mobilise resources, reconfigure governance structures, and respond to the challenges arising from the rapid dissemination of Generative Artificial Intelligence. This gap becomes even more relevant in environments characterised by high institutional complexity, in which the governance of technology depends on the interaction between multiple actors, rules, resources, and coordination mechanisms.

From this perspective, dynamic capabilities offer a promising analytical lens for understanding the governance of Artificial Intelligence not only as a set of norms or control mechanisms, but as an institutional capability geared towards continuous organisational adaptation in the face of technological transformations (TEECE, 2007; HELFAT *et al.*, 2007).

2.4 FEDERATED GOVERNANCE AS AN ORGANISATIONAL CAPABILITY FOR ARTIFICIAL INTELLIGENCE GOVERNANCE

The literature recognises that exclusively centralised or decentralised models present limitations in dealing with complex organisational environments, characterised by high interdependence, a multiplicity of actors, and the need for continuous coordination (GALBRAITH, 1973; WEILL; ROSS, 2004). While excessively centralised structures tend to reduce the autonomy and responsiveness of organisational units, excessively decentralised models may amplify problems of fragmentation, duplication of efforts, and strategic misalignment (WILLIAMSON, 1985; WEILL; ROSS, 2004).

In response to these limitations, different studies have highlighted the importance of hybrid governance mechanisms capable of combining institutional coordination, operational autonomy, and strategic alignment. Such arrangements seek to balance control and flexibility, allowing different organisational units to preserve the capacity for local initiative without compromising the institutional coherence and strategic objectives of the organisation (WEILL; ROSS, 2004; JANSSEN; VAN DER VOORT, 2020).

However, investigations that analyse federated governance applied specifically to Artificial Intelligence in the public sector are still limited. Although the literature recognises the need for coordination mechanisms to deal with the risks, opportunities, and impacts of AI, studies focused on regulation, ethical principles, and normative frameworks predominate, devoting less attention to the organisational arrangements necessary to operationalise governance in complex environments (WIRTZ *et al.*, 2020; ZUIDERWIJK *et al.*, 2021; OECD, 2024).

This gap becomes particularly relevant in structures characterised by shared services, multiple bodies, different levels of digital maturity, and distributed decision-making autonomy. In these contexts, the governance of Artificial Intelligence depends on the institutional capacity to coordinate diverse interests, share resources, manage risks, and promote innovation simultaneously. Understanding how federated governance mechanisms contribute to balancing organisational autonomy, institutional oversight, and technological innovation therefore constitutes a theoretical and practical challenge still insufficiently explored by the literature.

From this perspective, federated governance can be understood not only as a structural arrangement for the distribution of responsibilities, but as an organisational capability geared towards the coordination of complex environments, offering a promising analytical lens for understanding the governance of Artificial Intelligence in the public sector (WEILL; ROSS, 2004; GALBRAITH, 1973).

2.5 AGILE BUREAUCRACY AND ADAPTIVE GOVERNANCE IN THE AGE OF ARTIFICIAL INTELLIGENCE

There is growing consensus that digital transformation requires more adaptive forms of public governance, capable of responding to the speed of technological changes without compromising fundamental principles of public administration, such as transparency, accountability, and institutional control (MERGEL, 2016; JANSSEN; VAN DER VOORT, 2020). In this context, agile bureaucracy emerges as an alternative for reconciling innovation and oversight, replacing excessively rigid mechanisms with more flexible approaches oriented towards continuous learning and organisational adaptation (MERGEL, 2016; MERGEL *et al.*, 2019).

This challenge becomes particularly relevant in the governance of Artificial Intelligence. The rapid evolution of intelligent systems, especially of applications based on Generative AI, frequently surpasses the responsiveness of traditional bureaucratic models, expanding the need for oversight mechanisms proportional to risk and capable of adapting to technological dynamics (OECD, 2024; NIST, 2023; UNESCO, 2024). Thus, the governance of AI requires organisational structures that reconcile innovation, risk management, and institutional compliance simultaneously.

Although the literature recognises the importance of adaptive governance in dealing with emerging technologies, studies that empirically analyse how principles associated with agile bureaucracy can be operationalised in the governance of Artificial Intelligence in complex public organisations are still limited (JANSSEN; VAN DER VOORT, 2020; WIRTZ *et al.*, 2020). How mechanisms of risk-based oversight, institutional coordination, and continuous adaptation contribute to the development of institutional capabilities capable of balancing technological innovation and public accountability remains particularly poorly understood.

2.6 THEORETICAL SYNTHESIS AND RESEARCH GAP

The review of the literature reveals a growing consensus that the governance of Artificial Intelligence should ensure that the technology is used in a safe, transparent, responsible manner and oriented towards the creation of public value (OECD, 2024; UNESCO, 2024; NIST, 2023). In parallel, different theoretical currents converge in recognising that the creation of public value depends on the articulation between institutional outcomes, legitimacy, and operational capacity, especially in environments characterised by multiple actors, shared resources, and high organisational interdependence (MOORE, 1995;

BRYSON *et al.*, 2014; OSBORNE, 2021). In this context, the dissemination of Generative Artificial Intelligence expands the need for governance mechanisms capable of balancing innovation, oversight, risk management, and accountability, particularly in complex public organisations.

The literature also recognises that organisational environments of this nature demand coordination structures capable of reconciling autonomy, strategic alignment, and institutional oversight (GALBRAITH, 1973; WEILL; ROSS, 2004). Likewise, there is growing recognition that continuous adaptation to technological transformations depends on the development of organisational capabilities geared towards the identification of opportunities, the mobilisation of resources, and the permanent reconfiguration of structures and processes (TEECE, 2007; HELFAT *et al.*, 2007). Complementarily, approaches associated with agile bureaucracy highlight the need for adaptive governance mechanisms capable of responding to the speed of technological changes without compromising the fundamental principles of public administration (MERGEL, 2016; JANSSEN; VAN DER VOORT, 2020).

Despite these advances, studies that empirically investigate how public organisations develop institutional capabilities to govern Artificial Intelligence in contexts characterised by high organisational complexity remain limited. In particular, there is a scarcity of research that integrates the perspectives of Artificial Intelligence Governance, Public Value, Dynamic Capabilities, Federated Governance, and Agile Bureaucracy into a single interpretative model. Accordingly, this study analyses the governance of Artificial Intelligence not only as a set of norms or control mechanisms, but as an institutional capability constructed through the interaction between organisational coordination, continuous adaptation, risk-based oversight, and orientation towards the creation of public value. From this perspective, the case of the Ministry is used as an empirical lens to understand how public organisations develop capabilities to govern Artificial Intelligence in environments characterised by high institutional complexity.

Figure 1

Analytical Model of the Research



Source: prepared by the author.

Thus, Figure 1 synthesises the analytical model adopted in this study. The model proposes that the construction of the institutional capability to govern Artificial Intelligence in

the public sector results from the interaction between AI governance mechanisms oriented towards the creation of public value, dynamic capabilities of organisational adaptation, and coordination structures represented by federated governance and agile bureaucracy. From this perspective, the research seeks to understand how these elements are articulated in organisational contexts characterised by high institutional complexity.

3 METHODOLOGY

3.1 RESEARCH DESIGN

This study adopts a qualitative approach, of an exploratory and descriptive nature, developed through an instrumental single-case study (Yin, 2018). The choice of this strategy is grounded in the need to understand how public organisations develop institutional capabilities to govern Artificial Intelligence in contexts characterised by high organisational complexity.

The case analysed corresponds to the MGI, selected here for its relevance to the digital transformation agenda of the Federal Public Administration and for the recent institutionalisation of formal mechanisms of Artificial Intelligence governance. More than understanding a specific experience, the study uses the case as an analytical lens to examine the organisational mechanisms involved in the construction of the institutional capability to govern emerging technologies.

As support for the preparation of the manuscript, generative Artificial Intelligence tools were used, including ChatGPT (OpenAI), Gemini, and NotebookLM (Google), exclusively for activities supporting academic writing, textual organisation, language revision, synthesis of content, and the preparation of conceptual graphical representations.

These tools were not employed for the collection, production, treatment, or analysis of the research data, nor for the interpretation of the results or the formulation of the conclusions. All decisions related to the research design, selection of sources, theoretical foundation, methodological procedures, analysis of findings, and preparation of the conclusions were conducted and validated by the authors, who assume full responsibility for the scientific content presented.

3.2 UNIT OF ANALYSIS AND SOURCES OF EVIDENCE

The unit of analysis corresponds to the Artificial Intelligence governance structure established within the MGI, comprising its normative mechanisms, organisational arrangements, coordination instruments, and oversight processes.

The research was based predominantly on document analysis. Normative, strategic, and operational documents related to the governance of Artificial Intelligence, digital governance, data governance, and risk management were examined. Among the main sources analysed, the following stand out: Portaria MGI nº 3.485/2026 (Brasil, 2026), the Resolutions of the Comitê de Governança Digital e Segurança da Informação (CGDSI), strategic Artificial Intelligence documents, technical reports (BRASIL, 2025a; BRASIL, 2025b; BRASIL, 2025c; BRASIL, 2026), and international normative references, including the ISO/IEC 23894, ISO/IEC 38507, and ISO/IEC 42001 standards (ABNT, 2022; ABNT, 2023; ABNT, 2024).

The use of multiple documentary sources sought to expand the robustness of the investigation through the triangulation of evidence and the traceability of the results.

3.3 ANALYSIS PROCEDURES

The documents were subjected to thematic analysis (BRAUN; CLARKE, 2006), a technique widely used in qualitative research for the identification, organisation, and interpretation of patterns of meaning present in the data.

The analysis was conducted in four stages. Initially, an exploratory reading of the documents was carried out, along with the identification of content related to the governance of Artificial Intelligence. Subsequently, the passages considered relevant were coded and grouped into thematic categories. In the third stage, the evidence was organised according to the central constructs of the theoretical framework: Artificial Intelligence Governance, Public Value, Dynamic Capabilities, Federated Governance, and Agile Bureaucracy. Finally, the results were interpreted in the light of these categories, seeking to understand how the observed mechanisms contribute to the construction of institutional capabilities for AI governance.

The analytical strategy adopted was predominantly deductive, since the categories used derive directly from the theoretical framework guiding the research.

3.4 ETHICAL CONSIDERATIONS AND RESEARCH QUALITY

The research used exclusively institutional, normative, and technical documents, not involving the collection of personal data or the direct participation of individuals. Thus, there was no treatment of sensitive information or identification of participants.

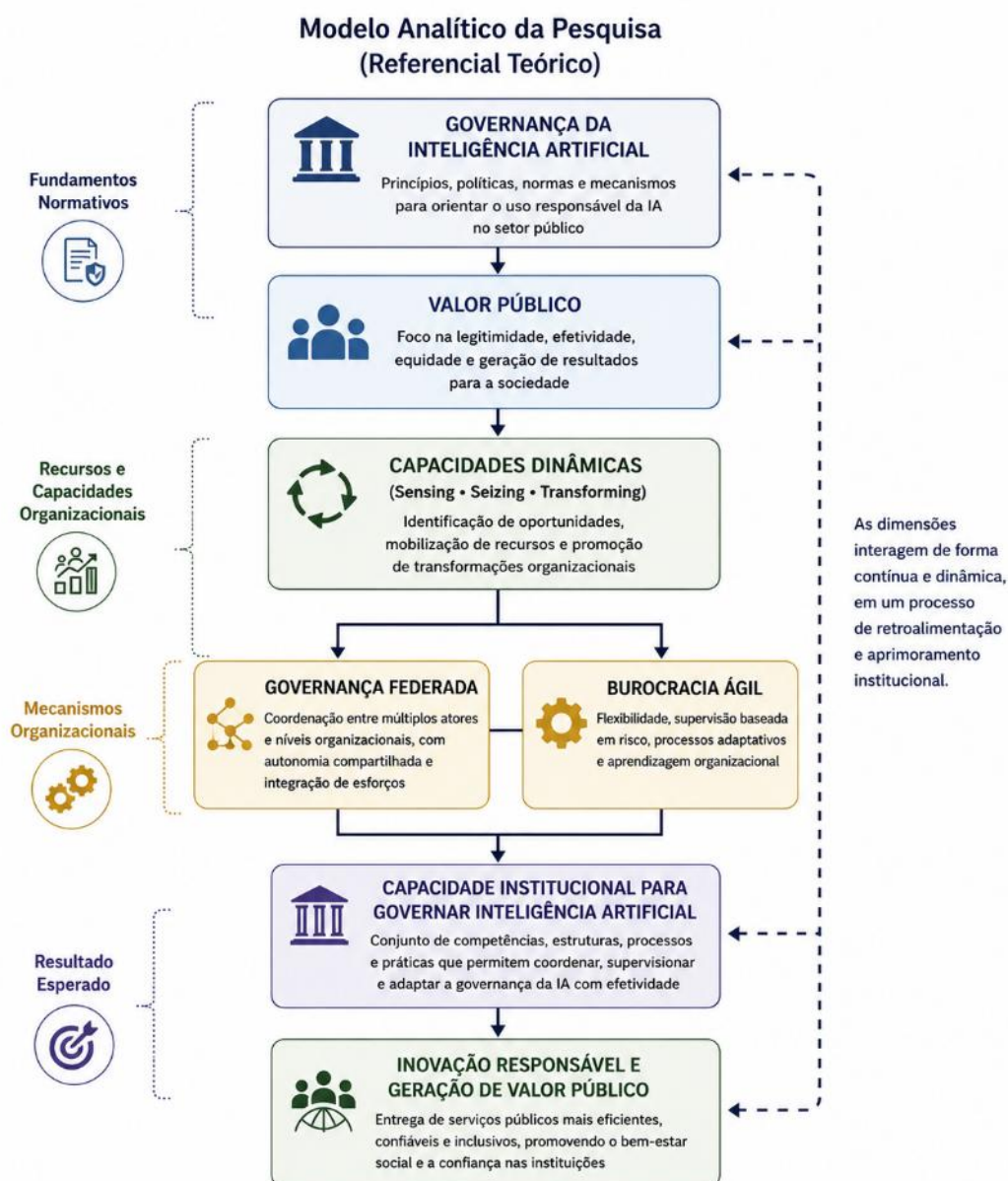
To strengthen the reliability of the results, documentary triangulation, the use of multiple sources of evidence, and the alignment between the analytical categories and the theoretical constructs of the research were adopted. Additionally, the description of the

methodological procedures seeks to ensure transparency and to allow the replication of the analytical strategy adopted.

3.5 RESEARCH LIMITATIONS

As with any single-case study, the results should be interpreted considering the specificities of the institutional context analysed. The objective of the research is not to produce statistical generalisations, but to generate analytical contributions that can be transferred to similar organisational contexts.

Furthermore, the investigation is based predominantly on document analysis. Although this strategy provides high traceability of the evidence analysed, future studies may complement the results through interviews with managers, specialists, and users involved in the implementation of Artificial Intelligence initiatives.

Figure 2*Research Methodology*

Source: prepared by the author.

Figure 2 synthesises the methodological path adopted in the research. The methodological design combined an instrumental single-case study, document analysis, and triangulation of evidence, enabling examination of the construction of institutional capabilities for the governance of Artificial Intelligence in the context of the Ministry. The strategy adopted sought to ensure coherence between the theoretical framework, the sources of evidence, and the analytical procedures employed in the interpretation of the results.

Finally, considering that AI governance constitutes a constantly evolving phenomenon, the results reflect a specific stage of institutional maturity, subject to transformations arising

from technological advances, regulatory changes, and the evolution of organisational practices.

4 ORGANISATIONAL CONTEXT AND CHALLENGES OF ARTIFICIAL INTELLIGENCE GOVERNANCE

The adoption of Artificial Intelligence (AI) in the public sector occurs in a context marked by the expansion of digital transformation initiatives, by the increase in organisational complexity, and by the need for coordination between multiple institutional actors (MERGEL *et al.*, 2019; JANSSEN; VAN DER VOORT, 2020). Unlike technologies traditionally implemented by central information technology areas, AI-based solutions, especially generative tools, tend to be incorporated directly by business areas, expanding the speed of innovation and the challenges associated with institutional oversight (OECD, 2024; NIST, 2023).

In this scenario, the Ministry constitutes a particularly relevant context for analysis. In addition to playing a strategic role in the digital transformation agenda of the Federal Public Administration, the Ministry is embedded in an environment characterised by the sharing of technological resources, a multiplicity of organisational actors, and high institutional interdependence. Such characteristics are frequently associated with contexts of high organisational complexity, in which coordination between different units becomes a critical element for governance and for the creation of public value (GALBRAITH, 1973; BRYSON *et al.*, 2014).

This complexity was amplified by the creation of ColaboraGov, established by Decreto nº 11.837, de 2023 (BRASIL, 2023), which set up the first Shared Services Centre of the Federal Public Administration. The model brings together different ministries and bodies in a structure geared towards the sharing of administrative and technological services, covering areas such as human resources management, budget, finance, accounting, and information technology.

From the perspective of technological governance, the model presents characteristics that significantly amplify the challenges of institutional coordination. The coexistence of multiple bodies served, different levels of digital maturity, a diversity of systems, shared contracts, and distinct organisational priorities produces an environment in which decisions related to Artificial Intelligence depend on the capacity to balance organisational autonomy and strategic alignment. This condition is frequently observed in federated governance models, in which different units retain the capacity for local initiative but operate under

common mechanisms of coordination and oversight (WEILL; ROSS, 2004; WILLIAMSON, 1985).

The dissemination of Generative Artificial Intelligence tools further intensified this challenge. The reduction of barriers to access to the technology expanded the experimentation capacity of organisational areas, but also increased the risks associated with the inadequate use of institutional data, technological fragmentation, and the development of initiatives outside the formal mechanisms of oversight (OECD, 2024; UNESCO, 2024). This phenomenon has reinforced the need for organisational structures capable of combining technological innovation, risk management, and institutional oversight on a continuous basis (NIST, 2023).

In this context, the governance of Artificial Intelligence ceases to represent merely a technological challenge and comes to constitute an organisational challenge. The capacity to innovate becomes directly dependent on the institutional capacity to coordinate different interests, oversee risks, promote strategic alignment, and ensure that the use of the technology remains compatible with the principles of public administration and with organisational objectives (JANSSEN; VAN DER VOORT, 2020; OECD, 2024).

In response to this scenario, the MGI began the construction of a specific Artificial Intelligence governance structure integrated into the already existing practices of digital governance, data governance, and information security. Among the main institutional milestones, the following stand out: the publication of Portaria MGI nº 3.485, de 2026 (BRASIL, 2026), the work of the Comitê de Governança Digital e Segurança da Informação (CGDSI), the creation of the Subcomitê de Inteligência Artificial (SCIA), and the integration of AI governance into the Ministry's Data Governance Policy (BRASIL, 2025a; BRASIL, 2025b; BRASIL, 2025c; BRASIL, 2026).

This approach converges with international recommendations that advocate the incorporation of AI governance into the already consolidated institutional mechanisms of management, risk, and compliance, avoiding parallel structures and promoting greater integration between technology, governance, and organisational strategy (ABNT, 2022; ABNT, 2024; OECD, 2024).

The analysis of the institutional documents indicates that the adopted model does not fit into a strictly centralised nor a fully decentralised logic. The existence of central mechanisms responsible for the definition of guidelines, risk criteria, minimum compliance requirements, and institutional oversight is observed, coexisting with the autonomy of organisational units to identify opportunities, propose initiatives, and develop solutions adhering to their specific needs.

This configuration approximates the concept of federated governance described by Weill and Ross (2004), in which strategic coordination and operational autonomy coexist as complementary governance mechanisms. More than distributing responsibilities, the model seeks to create institutional conditions for technological innovation to occur in a manner compatible with the requirements of information security, data governance, regulatory compliance, and the creation of public value.

Thus, the case analysed presents characteristics particularly relevant to the investigation proposed in this study. The combination of shared services, multiple bodies, different levels of autonomy, and the growing adoption of Artificial Intelligence configures an environment of high organisational complexity, suitable for examining how public organisations develop institutional capabilities to govern emerging technologies. From this perspective, the case allows for the empirical analysis of the interaction between dynamic capabilities (TEECE, 2007; HELFAT *et al.*, 2007), federated governance (WEILL; ROSS, 2004), and agile bureaucracy (MERGEL, 2016; JANSSEN; VAN DER VOORT, 2020), elements that constitute the analytical core of this research.

The characterisation of this context does not have a merely descriptive purpose. Its aim is to highlight the institutional conditions that justify the adoption of mechanisms of federated governance, agile bureaucracy, and the development of institutional capabilities for the governance of Artificial Intelligence, constituting the empirical basis for the analysis of the results presented in the following section.

5 RESULTS AND DISCUSSION

The document analysis allowed the identification that the Artificial Intelligence governance developed within the MGI was not structured as an isolated initiative, but incorporated into the already existing mechanisms of digital governance, data governance, and information security. The documents analysed reveal the creation of formal coordination bodies, risk-based oversight mechanisms, instruments to support innovation, and continuous processes of institutional adaptation (BRASIL, 2025a; BRASIL 2025b; BRASIL, 2026).

From the analysis carried out, four central dimensions (Table 1) associated with the construction of the institutional capability to govern Artificial Intelligence were identified: (i) institutional coordination; (ii) risk-based oversight; (iii) integration between governance and innovation; and (iv) continuous organisational adaptation.

Table 1*Synthesis of the main findings*

Identified Dimension	Observed Evidence	Associated Framework
Institutional Coordination	CGDSI, SCIA, and integration between digital governance, data, and security	Federated Governance
Risk-Based Oversight	Classification of initiatives and differentiated levels of oversight	Agile Bureaucracy
Integration between Governance and Innovation	Guidance, training, and controlled experimentation	Public Value
Continuous Organisational Adaptation	Inventory, monitoring, and normative updating	Dynamic Capabilities

Source: prepared by the author.

5.1 INSTITUTIONAL COORDINATION AND FEDERATED GOVERNANCE

The documents analysed reveal the work of the Comitê de Governança Digital e Segurança da Informação (CGDSI) as a strategic body responsible for the definition of institutional guidelines related to Artificial Intelligence, as well as that of the Subcomitê de Inteligência Artificial (SCIA) as a technical advisory structure responsible for the evaluation and monitoring of the proposed initiatives (BRASIL, 2026).

The integrated participation of the data governance, information security, and information technology structures in the evaluation processes of AI initiatives was also observed. This integration demonstrates that the governance of the technology was conceived in a transversal manner, involving different organisational competences and reducing decision-making fragmentation.

The findings indicate that the adopted model combines central coordination mechanisms with the autonomy of organisational units to identify opportunities and propose specific applications of Artificial Intelligence. This configuration approximates the concept of federated governance, characterised by the coexistence of strategic coordination and operational autonomy (WEILL; ROSS, 2004).

Unlike exclusively centralised or decentralised models, the observed structure seeks to balance institutional alignment, risk management, and local innovation capacity. This result reinforces the argument that complex organisational environments demand hybrid coordination mechanisms capable of reconciling autonomy and institutional integration (GALBRAITH, 1973; WILLIAMSON, 1985).

5.2 RISK-BASED OVERSIGHT AND AGILE BUREAUCRACY

The second dimension identified refers to the adoption of oversight mechanisms proportional to the risk associated with Artificial Intelligence initiatives.

The documents analysed reveal the existence of formal procedures for the classification of initiatives according to criteria related to data treatment, the criticality of the processes involved, potential impacts, and the level of autonomy of the proposed solutions (BRASIL, 2026). Based on this classification, different levels of evaluation and institutional monitoring are established.

It was observed that the intensity of oversight varies according to the risks identified, moving away from a uniform logic of control applicable indistinctly to all initiatives. Instead, the structure analysed adopts graduated governance mechanisms, compatible with the nature and potential impacts of each application.

This result adheres to the concept of agile bureaucracy, which proposes adaptive governance mechanisms capable of combining institutional control and operational flexibility (MERGEL, 2016). Likewise, it converges with the perspective of Janssen and Van der Voort (2020), according to which digital transformation requires more dynamic forms of oversight proportional to risk.

5.3 INTEGRATION BETWEEN GOVERNANCE AND INNOVATION

The third dimension observed refers to the integration between governance mechanisms and the promotion of innovation.

The institutional documents analysed indicate that the governance of Artificial Intelligence was conceived not only as an instrument of oversight, but also as a mechanism to stimulate the responsible use of the technology. Actions related to the guidance of demanding areas, user training, the dissemination of good practices, and the encouragement of the development of initiatives aligned with institutional guidelines were identified (BRASIL, 2026).

The results suggest that the structure analysed seeks to reduce organisational barriers to innovation without eliminating the necessary mechanisms of control and compliance. In this sense, governance comes to exercise simultaneously functions of oversight and inducement of innovation.

This finding converges with the recommendations of the OECD (2024) and UNESCO (2024), which advocate the construction of governance models capable of balancing technological innovation and risk management. It also approximates the conception of public value proposed by Moore (1995) and expanded by Bryson *et al.* (2014), in demonstrating that

governance can contribute simultaneously to institutional legitimacy, organisational efficiency, and the generation of socially relevant benefits.

5.4 DYNAMIC CAPABILITIES AND THE CONSTRUCTION OF THE INSTITUTIONAL CAPABILITY TO GOVERN AI

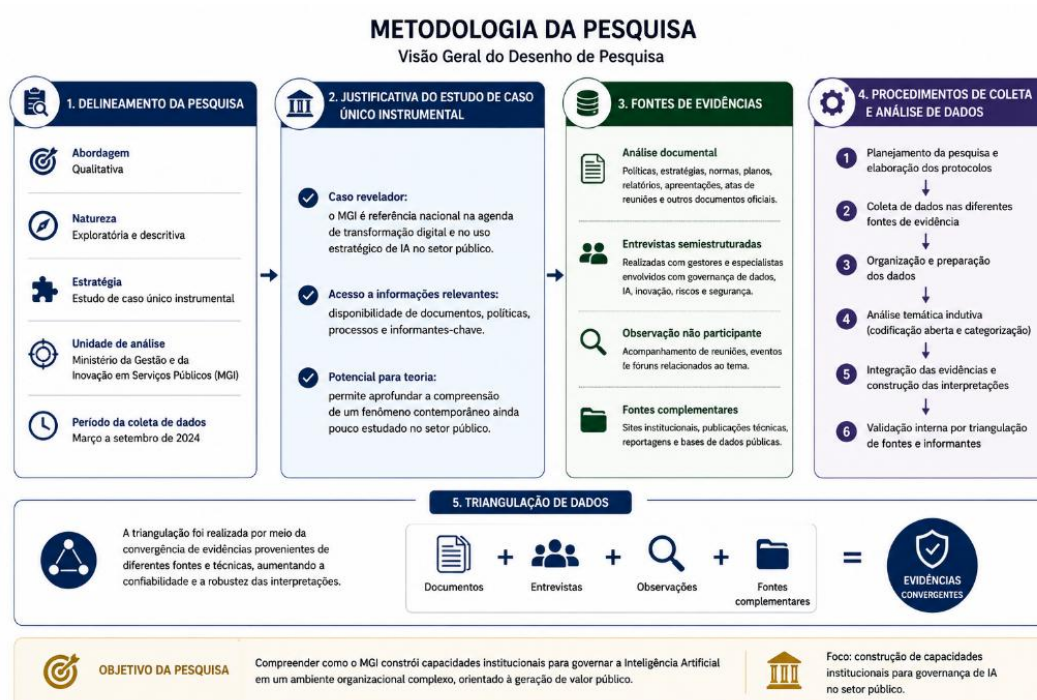
The fourth dimension identified refers to continuous organisational adaptation in the face of technological evolution.

The documents analysed reveal mechanisms geared towards the permanent monitoring of Artificial Intelligence initiatives, the updating of institutional guidelines, the revision of governance instruments, and the incorporation of new national and international normative references (BRASIL, 2026). Initiatives related to the training of civil servants, the inventory of AI solutions, and the continuous monitoring of the risks associated with the technology were also identified.

These elements indicate that the observed structure was conceived as a dynamic governance mechanism, subject to continuous improvements in response to technological, regulatory, and organisational changes.

From the perspective of dynamic capabilities, the results reveal the presence of the three dimensions proposed by Teece (2007). The identification of opportunities and risks associated with Artificial Intelligence approximates the sensing capability. The mobilisation of resources, governance structures, and coordination mechanisms relates to the seizing capability. Finally, the continuous updating of institutional practices reflects the transforming capability (TEECE, 2007; HELFAT *et al.*, 2007).

Taken together, the findings suggest that the governance observed in the case studied transcends the simple creation of norms or control structures. The results indicate the construction of permanent institutional capabilities geared towards coordination, oversight, innovation, and organisational adaptation. This institutional capability constitutes the main result observed and represents the main contribution of the study to the understanding of Artificial Intelligence governance in the public sector.

Figure 3*Interpretative Model of the Results*

Source: prepared by the author.

As illustrated in Figure 3, the four dimensions identified do not act in isolation. On the contrary, they constitute a dynamic governance system in which coordination, oversight, innovation, and organisational adaptation mutually reinforce one another. This interaction contributes to the formation of permanent institutional capabilities capable of sustaining the responsible adoption of Artificial Intelligence in complex organisational environments.

The results reinforce the central proposition of this study: the governance of Artificial Intelligence should not be understood only as a set of rules or compliance mechanisms, but as an institutional capability constructed through the interaction between federated governance, agile bureaucracy, dynamic capabilities, and orientation towards the creation of public value.

In the case analysed, this capability manifests itself through mechanisms of institutional coordination, risk-based oversight, integration between governance and innovation, and continuous organisational adaptation, which allow the reconciliation of organisational autonomy, risk management, and technological innovation in an environment characterised by high institutional complexity. Taken together, these dimensions contribute to the formation of permanent governance structures capable of sustaining the responsible adoption of Artificial Intelligence, expanding the state's capacity to generate public value without compromising the requirements of transparency, security, accountability, and

regulatory compliance. Figure 2 synthesises the interpretative model emerging from the research and the relationships identified between these dimensions.

6 CONCLUSION

This study aimed to analyse how public organisations develop institutional capabilities to govern Artificial Intelligence in contexts characterised by high organisational complexity. To this end, a qualitative case study was carried out within the MGI, using document analysis of normative provisions, governance instruments, and institutional documents related to the adoption and oversight of Artificial Intelligence.

The results indicate that the AI governance observed in the case studied was not constructed as an isolated mechanism of technological control. On the contrary, the incorporation of Artificial Intelligence into the already existing structures of digital governance, data governance, and information security was verified, resulting in the creation of integrated mechanisms of institutional coordination, risk-based oversight, the stimulation of responsible innovation, and continuous organisational adaptation.

The analysis allowed the identification of four central dimensions associated with the construction of the institutional capability to govern Artificial Intelligence: institutional coordination, risk-based oversight, integration between governance and innovation, and continuous organisational adaptation. Taken together, these dimensions reveal that AI governance transcends the simple elaboration of norms or formal control structures, constituting an organisational capability geared towards the coordination of technological innovation in complex and highly interdependent environments.

From a theoretical point of view, the study contributes to the literature by integrating perspectives traditionally analysed in isolation. The results suggest that the institutional capability to govern Artificial Intelligence can be understood as a result of the interaction between dynamic capabilities, federated governance mechanisms, agile bureaucracy practices, and orientation towards the creation of public value. This interpretation broadens the understanding of AI governance in the public sector by shifting the focus from a predominantly normative perspective towards an approach centred on the construction of organisational capabilities.

In practical terms, the findings offer subsidies for public organisations seeking to structure mechanisms of Artificial Intelligence governance without compromising innovation and organisational autonomy. The results indicate that models based exclusively on centralisation or decentralisation tend to present limitations in the face of the growing institutional complexity associated with digital transformation. In this context, federated

governance arrangements, combined with proportional oversight mechanisms, prove to be promising alternatives for balancing innovation, risk management, and strategic alignment.

As limitations, the study concentrated on a single organisational case and used predominantly documentary sources. Although this strategy allowed high traceability of the evidence analysed, the results should be interpreted considering the specificities of the institutional context investigated. Furthermore, the rapid evolution of Artificial Intelligence technologies suggests that governance structures and organisational mechanisms may undergo significant transformations over time.

Finally, future research may broaden the understanding of the phenomenon through comparative studies between different public bodies, investigations involving multiple organisational cases, and approaches that incorporate interviews with managers, specialists, and users. It also proves relevant to deepen the analysis of the relationships between federated governance, dynamic capabilities, and the creation of public value in contexts of growing adoption of Artificial Intelligence in the public sector.

It is concluded that governing Artificial Intelligence in the public sector consists not only of establishing rules, controls, or compliance requirements. It is, above all, a matter of developing institutional capabilities able to coordinate innovation, oversight, and organisational adaptation on a continuous basis, ensuring that the benefits of the technology remain aligned with the creation of public value.

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TERRITORIAL LISTENING AS AN EPISTEMOLOGICAL CATEGORY OF CONTEMPORARY RURAL EXTENSION

ESCUITA TERRITORIAL COMO CATEGORIA EPISTEMOLÓGICA DA EXTENSÃO RURAL CONTEMPORÂNEA

LA ESCUCHA TERRITORIAL COMO CATEGORÍA EPISTEMOLÓGICA DE LA EXTENSIÓN RURAL CONTEMPORÁNEA



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ABSTRACT

The literature on rural extension has demonstrated the limits of diffusionist and prescriptive models, particularly in the face of the growing recognition of participation, agroecology and territorial development. Nevertheless, the question of how territories participate in the very definition of the problems that orient extension action remains insufficiently explored. Departing from this gap, the article proposes the concept of territorial listening as an epistemological category of contemporary rural extension. Methodologically, a qualitative approach of a theoretical-analytical nature is developed, grounded in a critical review of the literature on rural extension, territoriality, the ecology of knowledges, social interfaces and socio-technical innovation. It is argued that the persistence of diffusionist traits in Technical Assistance and Rural Extension does not derive solely from the continuity of technology transfer mechanisms, but from the reproduction of institutional arrangements in which the definition of problems, priorities and responses remains concentrated outside the rural territories. In contrast, it is argued that territorial listening constitutes a systematic process of recognition, interpretation and problematisation of the rationalities, temporalities, conflicts, needs, expectations and knowledges that structure social life in the used territory. The analysis sustains that the principal weakness of many extension projects does not lie in the absence of technologies or resources, but in the insufficiency of institutional mechanisms capable of incorporating territories into the definition of the public problems that orient intervention. It is concluded that territorial listening operates as a mechanism for the redistribution of cognitive authority over the formulation of priorities, agendas and solutions, contributing to more legitimate processes of socio-technical innovation and rural development.

Keywords: Territorial Listening. Rural Extension. Territoriality. Epistemic Justice. Diffusionism.

RESUMO

A literatura sobre extensão rural tem demonstrado os limites dos modelos difusionistas e prescritivos, especialmente diante da crescente valorização da participação, da agroecologia e do desenvolvimento territorial. Entretanto, permanece insuficientemente explorada a questão de como os territórios participam da definição dos próprios problemas que orientam a ação extensionista. Partindo dessa lacuna, o artigo propõe o conceito de escuta territorial

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como categoria epistemológica da extensão rural contemporânea. Metodologicamente, desenvolve-se uma abordagem qualitativa, de natureza teórico-analítica, fundamentada em revisão crítica da literatura sobre extensão rural, territorialidade, ecologia dos saberes, interfaces sociais e inovação sociotécnica. Sustenta-se que a permanência de traços difusionistas na Assistência Técnica e Extensão Rural não decorre apenas da continuidade de mecanismos de transferência tecnológica, mas da reprodução de arranjos institucionais nos quais a definição dos problemas, das prioridades e das respostas permanece concentrada fora dos territórios rurais. Em contraposição, argumenta-se que a escuta territorial constitui um processo sistemático de reconhecimento, interpretação e problematização das racionalidades, temporalidades, conflitos, necessidades, expectativas e saberes que estruturam a vida social no território usado. A análise permite sustentar que a principal fragilidade de muitos projetos extensionistas não reside na ausência de tecnologias ou recursos, mas na insuficiência de mecanismos institucionais capazes de incorporar os territórios à definição dos problemas públicos que orientam a intervenção. Conclui-se que a escuta territorial opera como mecanismo de redistribuição da autoridade cognitiva sobre a formulação de prioridades, agendas e soluções, contribuindo para processos mais legítimos de inovação sociotécnica e desenvolvimento rural.

Palavras-chave: Escuta Territorial. Extensão Rural. Territorialidade. Justiça Epistêmica. Difusionismo.

RESUMEN

La literatura sobre extensión rural ha demostrado los límites de los modelos difusionistas y prescriptivos, especialmente ante la creciente valorización de la participación, la agroecología y el desarrollo territorial. Sin embargo, permanece insuficientemente explorada la cuestión de cómo los territorios participan en la definición de los propios problemas que orientan la acción extensionista. Partiendo de esta laguna, el artículo propone el concepto de escucha territorial como categoría epistemológica de la extensión rural contemporánea. Metodológicamente, se desarrolla un enfoque cualitativo, de naturaleza teórico-analítica, fundamentado en una revisión crítica de la literatura sobre extensión rural, territorialidad, ecología de los saberes, interfaces sociales e innovación sociotécnica. Se sostiene que la permanencia de rasgos difusionistas en la Asistencia Técnica y Extensión Rural no deriva únicamente de la continuidad de mecanismos de transferencia tecnológica, sino de la reproducción de arreglos institucionales en los cuales la definición de los problemas, de las prioridades y de las respuestas permanece concentrada fuera de los territorios rurales. En contraposición, se argumenta que la escucha territorial constituye un proceso sistemático de reconocimiento, interpretación y problematización de las racionalidades, temporalidades, conflictos, necesidades, expectativas y saberes que estructuran la vida social en el territorio usado. El análisis permite sostener que la principal fragilidad de muchos proyectos extensionistas no reside en la ausencia de tecnologías o recursos, sino en la insuficiencia de mecanismos institucionales capaces de incorporar los territorios a la definición de los problemas públicos que orientan la intervención. Se concluye que la escucha territorial opera como mecanismo de redistribución de la autoridad cognitiva sobre la formulación de prioridades, agendas y soluciones, contribuyendo a procesos más legítimos de innovación sociotécnica y desarrollo rural.

Palabras clave: Escucha Territorial. Extensión Rural. Territorialidad. Justicia Epistémica. Difusionismo.

1 INTRODUCTION

The critique of prescriptive rural extension already possesses a consolidated trajectory, since, ever since the contestation of agricultural modernisation and technological diffusion, a field of reflection has been formed that questions the pretension of universalising technical packages, institutional languages and external criteria of efficiency as though they were naturally adequate responses to rural realities (Caporal, 1998; Thiollent, 1984; Stroparo, 2025a).

Despite this critical accumulation, central traits of this pattern remain present in extension practices, including in contexts in which the institutional lexicon has come to value participation, agroecology, sustainability and territorial development (Diniz; Hespanhol, 2019; Grígolo *et al.*, 2015; Zarnott *et al.*, 2017).

This inflection also finds support in the conception of university extension consolidated by the Fórum de Pró-Reitores de Extensão das Instituições Públicas de Educação Superior Brasileiras (FORPROEX), which defines it as an interdisciplinary, educational, cultural, scientific and political process capable of promoting transformative interaction between university and society (FORPROEX, 2012). Although formulated within the scope of university extension, this perspective contributes to questioning unidirectional models of intervention and reinforces the need to understand the production of knowledge as a relational, dialogical and socially situated process.

This mismatch suggests that the problem of contemporary extension is not limited to the inadequacy of instruments or methodologies. Its most persistent core lies in the way problems, priorities and solutions continue to be defined from institutional centres external to the territories, relegating farmers and rural collectives to the condition of recipients, informants or beneficiaries of previously formulated agendas (Deponti; Almeida, 2012; Samborski *et al.*, 2017).

In this sense, the persistence of diffusionism should be read less as the survival of outdated techniques and more as the reproduction of a grammar of power over knowledge.

The current literature has produced important advances by emphasising participation, dialogue, shared construction of knowledge and the valorisation of local knowledges. Nevertheless, these approaches do not always explicitly confront a prior question: who participates in the definition of the very problems that orient intervention?

In many cases, farmers and communities are invited to collaborate in the implementation, adaptation or validation of solutions, but not necessarily in the formulation of the agendas that structure extension action. At times, they are subjected to imposing protocols that deterritorialise the community's knowledges and alter processes.

This gap suggests the need for an analytical category capable of understanding how territories interfere in the constitution of the public problems that mobilise rural extension; and it is precisely at this point that the concept of territorial listening acquires analytical relevance, since to listen to the territory does not merely mean to gather local data, apply rapid diagnoses or collect declared preferences, but to recognise the territory as a web of social relations, uses, conflicts, scales of power, temporalities and situated knowledges, from which problems and solutions must be constructed (Santos, 2002; Schneider; Tartaruga, 2004, 2005).

More than a technique of approximation, territorial listening is conceived here as a condition of possibility for a post-diffusionist extension: it reorganises the relationship between knowledge and intervention, because it displaces the legitimate definition of the problem from the institutional centre to the territorial interfaces where actors, norms, experiences and socio-technical objects enter into relation (Deponti; Almeida, 2012; Jasanoff, 2004; Samborski *et al.*, 2017).

The argument of the article is organised around four theses: a) that territorial listening constitutes a critique of diagnostic exteriority, because it requires submitting the institutional questions themselves to the test of territorial rationalities (Deponti; Almeida, 2012; Thiollent, 1984); b) the thesis that it operates as a relational theory of the territory, refusing the reading of rural space as a mere receptacle of demands and taking it as a historical configuration of powers, belongings, uses and conflicts (Raffestin, 1987; Santos, 2002; Schneider; Tartaruga, 2004); c) territorial listening as a principle of epistemic justice, since the legitimate definition of problems depends on the co-presence, confrontation and translation between heterogeneous knowledges (Santos *et al.*, 2006; Sousa, 2015; Torres-Rego, 2022); and d) as a socio-technical condition of innovation, since durable solutions tend to arise from processes of co-production anchored in the territory (Cotrim, 2017; Jasanoff, 2004; Rist, 2009).

The contribution of the text, therefore, consists in consolidating territorial listening as an epistemological category of contemporary rural extension, whose methodological and political ramifications are discussed throughout the article.

Rather than treating it as an auxiliary technique of participation, it is argued that territorial listening simultaneously redefines what counts as a problem, who may legitimately name it and under what conditions a solution may be considered pertinent. The objective, therefore, is to analyse the limits of prescriptive extension models and to discuss territorial listening as the foundation of processes of territorially contextualised socio-technical innovation.

The argument develops in six movements: the diffusionist heritage of extension; the relationship between knowledge, power and the definition of problems; the articulation between territorial listening and territoriality; the passage from transfer to co-production; the redefinition of the role of the extension agent; and, finally, the formulation of a new extension paradigm.

2 METHODOLOGY

The article is characterised as a theoretical-analytical study of a qualitative nature, based on interpretative bibliographical review and conceptual reconstruction (Guerra *et al.*, 2024). Its purpose is not to measure the empirical incidence of specific extension practices, but to critically examine a tradition of debate and, on that basis, to propose the concept of territorial listening as an analytical category of contemporary rural extension.

The bibliographical corpus was composed of classical and contemporary authors pertinent to six articulated axes: critique of diffusionism and prescriptive extension; agroecology and the social construction of knowledge; knowledge, power and the definition of problems; territory and territoriality; actor-oriented approach and rural development; and socio-technical innovation and co-production. The selection privileged the Brazilian and Latin American debate on rural extension and territorial development, without excluding international contributions indispensable to the conceptual formulation of the problem. In this composition, institutional landmarks such as PNATER and ANATER were mobilised not as a central autonomous object, but as historical and normative evidence of the tensions between participatory orientation and diffusionist persistence.

From the analytical point of view, the procedure adopted consisted of three complementary movements. The first was reconstructive, aimed at identifying the theoretical and political limits of the prescriptive paradigm of extension. The second was relational, seeking to articulate the contributions of authors of the territory, the ecology of knowledges, communicative action, social interfaces and socio-technical co-production. The third was propositional, oriented towards the systematisation of territorial listening as a concept endowed with epistemological, methodological and political reach.

Thus, the methodology does not operate as a stage external to the argumentation, but as a form of reflexive organisation of the article's own theoretical trajectory.

3 RESULTS AND DISCUSSION

3.1 THE PERSISTENCE OF THE PRESCRIPTIVE PARADIGM IN RURAL EXTENSION

The diffusionist tradition structured much of the extension institutionality by treating innovation as a linear sequence: research generates solutions, extension transmits them and farmers adopt them at distinct rhythms (Rogers, 2003; Rist, 2009).

In this context, knowledge appears as a finished product, separated from its contexts of use, and farmers enter the process above all as recipients of change. Thiollent's classical critique shows that this model is not only technically limited, but ideologically oriented (Thiollent, 1984). By taking modernisation as an indisputable horizon, technological diffusion converts communication into persuasion, individualises the success or failure of adoption and obscures the social, cultural and ecological conditions that shape agricultural practices. The problem, therefore, lies not only in the vertical transmission of technique, but in the presupposition that the relevant responses are already defined before the encounter with social reality.

In the Brazilian literature, this legacy remains a central negative reference for the critical revision of ATER (Technical Assistance and Rural Extension), where, for example, Caporal argues that conventional extension, supported on the diffusion of innovations, is insufficient to respond to the challenges of sustainable development, precisely because it separates technology, context and social participation (Caporal, 1998).

From a similar perspective, Long (2001) argues that rural interventions do not bear upon passive contexts, but upon arenas composed of actors who continually interpret, negotiate and reconfigure external proposals. On the other hand, the heterogeneity of modes of production and of strategies of social reproduction in the countryside renders particularly problematic the presumption of universally valid solutions for distinct rural contexts (Ploeg, 2008).

Later, the institutional inflection represented by PNATER sought to break with this pattern by incorporating agroecology, participation and social diversity as guiding principles (Diniz; Hespanhol, 2019). However, the normative reorientation did not eliminate the persistence of hierarchical routines, bureaucratic overload, decision-making centralisation and the instrumental use of extension agents as executors of programmes (Diniz e Hespanhol, 2019).

The persistence of diffusionist elements also appears when the territorial language is incorporated merely by addition. Grígolo *et al.* (2015) show that the reference to the territory does not always produce substantive change, since it frequently confines itself to expanding the institutional vocabulary without altering capacities, routines and forms of coordination.

The territory comes to figure as a new administrative scale, not as a principle of reorganisation of intervention. Zarnott *et al.* (2017), for example, identify a similar process when analysing the tension between the critical orientation of PNATER and the recomposition of a more technocratic agenda around ANATER.

The persistence of diffusionism, therefore, does not derive from simple doctrinal lag, but expresses the resilience of a form of power that stabilises the institutional priority of supply over listening, of solution over problem and of prescription over mediation. It is this structure that needs to be denaturalised so that the territories themselves may participate in the definition of the problems, priorities and solutions that orient extension action.

If the persistence of the prescriptive paradigm does not derive solely from the maintenance of diffusion techniques, but from the reproduction of institutionalised forms of problem definition, then the central question of rural extension shifts from the choice of solutions to the processes by which certain demands acquire public legitimacy.

3.2 KNOWLEDGE, POWER AND THE DEFINITION OF PROBLEMS

The critique of prescriptive extension becomes more rigorous when it displaces the focus from technologies to the politics of problem definition, since before asking which techniques should be promoted, one must question who names the deficiency, who hierarchises priorities and in what language a problem becomes recognisable to the institutional apparatus. At this point, extension reveals itself as a practice of power over knowledge.

The analysis of social interfaces formulated by Deonti and Almeida (2012) is especially fruitful for this displacement. It is understood that public intervention does not operate as the simple linear execution of a project, but as an arena in which distinct lifeworlds meet, negotiate, silence, resist and translate expectations.

In this sense, the extension agent does not deal with a homogeneous public, but with actors who possess their own resources, margins of manoeuvre and selective forms of adherence. Refusal itself, silence or low participation may constitute active responses to external agendas (Deonti; Almeida, 2012).

This implies recognising that the definition of the problem is not neutral, since prescriptive models tend to convert diagnosis into a stage of legitimising already known responses, where data collection thus occurs to confirm the pertinence of projects formulated before the real interaction with the territory. In contrast, dialogical approaches sustain that the situation of action must be constructed intersubjectively, with the application of the theory of communicative action (Feenberg, 1996; Habermas, 1984). Therefore, the legitimacy of

intervention depends on the negotiation of common definitions, and never on the imposition of technical criteria and/or the beliefs of researchers (Samborski *et al.*, 2017).

When the farmer is treated as the object of educational action, the extension practice reproduces a logic of cultural invasion. Problematisation, on the contrary, requires that the programmatic content arise from the concrete relationship of the subjects with their world and that the project make sense for those who will participate in it (Torres-Rego, 2022).

The same inflection appears in the so-called pedagogy of inquiry, in which listening, knowing practices and problematising compose a methodological sequence oriented by immersion in reality, and not by the advance transmission of responses (Marinho *et al.*, 2022).

Dealing specifically with the literature on the construction of agroecological knowledge, one verifies the discourse that scientific knowledges and local knowledges should not merely be juxtaposed, but articulated around questions that are effectively relevant to the context (Sousa, 2015).

From this perspective, the problem does not pre-exist as an objective datum available for more qualified technicians to identify it but, on the contrary, is socially constructed in processes of interpretation, conflict and translation. For this reason, the inequality between knowledges is not a methodological detail, but a central component of the power relation that structures extension action.

The notion of territorial listening arises precisely in this context, since it is not merely a matter of the actors' opinion on possible solutions, but of the prior process by which needs, urgencies and horizons of action are named, disputed and stabilised.

To listen, therefore, is to admit that the problem is not yet entirely given and that its adequate formulation depends on the encounter between different regimes of knowledge. For this reason, territorial listening does not begin with the community response to an institutional question, but with the critical suspension of the question itself, that is, with the disposition to submit the initial technical framing to the test of territorial rationalities (Deponti; Almeida, 2012; Marinho *et al.*, 2022; Thiollent, 1984).

Therefore, by displacing attention from solutions to the processes of problem definition, territorial listening introduces an additional question: where are the rationalities formed that orient collective needs, priorities and expectations? Answering this question requires understanding the territory not only as a space of intervention, but as a relational configuration in which knowledges, powers, belongings and conflicts are continually produced. It is in this sense that the discussion on territoriality becomes central to the conceptual formulation of territorial listening.

3.3 TERRITORIAL LISTENING AND TERRITORIALITY

If the definition of problems is situated, listening must also be so, since the territory cannot be reduced to an administrative delimitation or a physical base where programmes bear and extension teachers develop their projects according to their own beliefs and methods. In the tradition that articulates Milton Santos and Sérgio Schneider, the territory is a field of relations, uses, powers, identities, flows and disputes, that is, a social reality produced and lived (Santos, 2002; Schneider; Tartaruga, 2004).

The immediate consequence of this premise is that listening to the territory is not equivalent to hearing isolated individuals, but to interpreting relational configurations through which actors, institutions, technical objects and scales of power are articulated.

To make this argument explicit, it is convenient to formulate territorial listening in four complementary conceptual theses: a) Territorial listening is a critique of diagnostic exteriority, where diffusionism is characterised not only by transmitting ready-made responses, but is characterised, even prior to that, by supposing that the problem can already be known from outside, according to technical categories whose validity would be prior to the encounter with the territory (Rist, 2009; Thiollent, 1984).

To listen territorially, therefore, breaks with this presupposition, given that listening does not begin when the institution asks the territory how best to implement a solution, but begins when the very formulation of the problem becomes revisable in the face of territorial rationalities (Marinho *et al.*, 2022).

Its first gesture, therefore, is epistemologically negative: to suspend the diagnostic self-sufficiency of the institution. At this point, territorial listening approaches a critique of heteronomous intervention, because it refuses the naturalisation of agendas elaborated in other centres of calculation and decision (Diniz; Hespanhol, 2019; Thiollent, 1984).

The second thesis sustains that territorial listening is a relational theory of rural space; as Santos (2002) asserts, the territory must be understood as a used territory, an indissociable combination of objects and actions (Santos, 2002). This formulation is decisive because it prevents rural space from being treated as a neutral scenario; beyond the presence of resources, infrastructures or productive units, it concerns the way in which these elements are appropriated in concrete practices, under tensions between external verticalities and the horizontalities of local life (Santos, 2002).

In other words, the territory is traversed by external commands, but also by bonds of proximity, solidarity, experience and resistance. Under this key, territorial listening is not confused with an inventory of local assets, but requires apprehending how the uses of space

condense disputes over time, work, the circulation of information, access to resources and the possibility of social permanence.

Schneider and Tartaruga deepen this view by distinguishing territory as an analytical category and territorial approach as a mode of intervention (Schneider; Tartaruga, 2004, 2005). The distinction is relevant, since while the territorial approach may be appropriated normatively by public policies, the concept of territory refers to relations of power, sense of belonging, social consciousness, distributive conflicts and forms of coordination among actors (Schneider; Tartaruga, 2004).

This means that territorial listening cannot be defined by mere geographical proximity between State and population, but depends on the capacity to reconstruct, within the intervention, the effective mediations through which the subjects self-identify, name their losses, recognise their bonds and perceive their margins of action (Schneider; Tartaruga, 2005).

In this interim, territoriality ceases to be a secondary attribute and comes to function as a central mediation. If the territory is the spatialisation of social and power relations, territoriality may be understood as the set of practices, meanings, appropriations and codes of belonging through which the actors live, delimit and dispute that space (Raffestin, 1987; Schneider; Tartaruga, 2004).

Territorial listening operates, therefore, upon this relational thickness, where it seeks to capture not only what the actors say about the territory, but how the territory is continually produced in their strategies of social reproduction, in their distributive conflicts and in their everyday forms of coordination (Deponi; Almeida, 2012; Santos, 2002). For this reason, its unit of reference is not the locality in itself, but the bundle of relations that makes it exist as a socially significant territory.

The next thesis sustains that territorial listening is a principle of epistemic justice, where the theoretical density of the concept depends on its epistemological base. The ecology of knowledges offers here a decisive step, because it allows breaking with the idea that technical knowledge holds, by itself alone, the competence to adequately name rural reality (Santos *et al.*, 2006; Sousa, 2015).

If different forms of knowledge participate in the intelligibility of the social world, territorial listening cannot be thought of as the simple collection of information to be subsequently translated by the specialist but, on the other hand, must be conceived as a device of recognition of the co-presence of heterogeneous rationalities, whose articulation is always partial, conflictive and situated (Santos *et al.*, 2006; Torres-Rego, 2022). To listen

territorially is, therefore, to redistribute the authority to interpret reality and to define what counts as relevant evidence for action.

The theory of communicative action reinforces this argument by showing that the validity of an intervention cannot rest solely on instrumental effectiveness (Habermas, 1984, 2015). Extension action gains legitimacy and trust when the participants can negotiate common definitions of the situation and submit claims to truth, correctness and sincerity to processes of understanding (Samborski *et al.*, 2017).

From this point of view, territorial listening is not a preparatory stage prior to intervention proper, but is itself the communicative mediator through which intervention ceases to be a strategic imposition and may become reflexive coordination of action.

To listen is to open the technical problem to the test of the social world and the subjective world, and not merely to verify the local adherence of a predefined solution. Epistemic justice, here, is not reduced to recognising subalternised knowledges, but implies constructing procedures by which such knowledges may effectively interfere in the course of the public definition of problems.

Finally, the fourth thesis sustains that territorial listening is a socio-technical condition of actor-oriented innovation; and the analysis of social interfaces shows that public interventions do not enter empty territories, but traverse arenas already structured by strategies, memories, inequalities and their own resources (DePonti; Almeida, 2012; Long, 2001; Long; Ploeg, 1989).

From this perspective, territorial listening must be understood as a reading of the interfaces in which external projects are appropriated, negotiated, deflected or refused. Its unit of analysis is neither the abstract individual nor the idealised community, but the interface where distinct social worlds meet and redefine the course of action (DePonti; Almeida, 2012). This explains why silence, partial adherence and the selective translation of programmes are as relevant as the explicit manifestations of demand.

There is yet another reason to treat territorial listening as a socio-technical category and not merely a sociological one. The literature on co-production shows that problems, evidence, solutions and institutions constitute one another mutually (Jasanoff, 2004; Rist, 2009). Technologies do not arrive ready-made in a previously given social milieu, but reorder relations, distribute capacities and stabilise certain visions of the future, while at the same time being transformed by local uses, resistances and adaptations (Rist, 2009; Stroparo, 2025b).

Territorial listening also requires recognising that the subjects do not belong to a single territory, but transit through multiple territorialities simultaneously. As Haesbaert (2004, 2007)

argues, contemporary territories are marked by processes of multiterritoriality in which different belongings, networks, scales of power and forms of use of space coexist and, frequently, enter into tension. Under this perspective, to listen to the territory does not mean seeking a homogeneous voice of the community, but understanding the socio-territorial textures produced by the interaction between diverse and, at times, conflicting rationalities.

Territorial listening thus becomes the mechanism by which extension can accompany this co-production instead of denying it. To listen is not to delay innovation, but to create the conditions for it to emerge as a territorially intelligible and politically legitimate solution. As a consequence, innovation ceases to be measured solely by adoption and technical performance and comes to be judged also by its capacity to respond to effectively territorialised problems.

In the light of these four theses, territorial listening may be defined as a systematic process of recognition, interpretation and problematisation of the rationalities, temporalities, conflicts, needs, expectations and situated knowledges that structure the used territory. It is an epistemological process because it displaces the production of extension knowledge from the verification of external hypotheses to the co-production of intelligibility about local reality (Santos *et al.*, 2006; Sousa, 2015).

It is, furthermore, a methodological process because it requires observation, dialogue, restitution, interpretative comparison and continual revision of the initial framing, so as to capture not only explicit discourses, but also silences, resistances, self-identifications and distinct scales of belonging (De Ponti; Almeida, 2012; Kersten; Ison, 1998; Marinho *et al.*, 2022).

Consequently, it is a political process because it redistributes the authority to define what matters, which problems deserve priority and under what criteria a solution may be considered pertinent (Samborski *et al.*, 2017; Torres-Rego, 2022).

The four theses discussed converge towards an expanded understanding of territorial listening. In the first place, it constitutes a critique of diagnostic exteriority by questioning the possibility of the prior definition of problems independently of territorial rationalities. Then, it operates as a relational theory of the territory by understanding rural space as a historical configuration of uses, belongings, conflicts and power relations. In the third place, it affirms itself as a principle of epistemic justice by recognising that the legitimate definition of problems depends on the interaction between different forms of knowledge. Finally, it presents itself as a socio-technical condition of innovation, since durable solutions tend to emerge from processes of negotiation, translation and territorially situated co-production. Considered together, these dimensions allow understanding territorial listening as an

epistemological category capable of reorienting extension action beyond the logic of transfer and prescription.

This formulation allows differentiating territorial listening from three impoverished readings. The first reduces it to an initial gathering of data to calibrate already decided projects. The second converts it into a generic participatory repertoire, disconnected from the materiality of territorial relations. The third interprets it as a mere ethical attitude of professional sensitivity, without consequences for the distribution of cognitive authority in intervention. In all these cases, the link between listening, territoriality and the redefinition of the very form of producing public problems in the rural milieu is lost. To listen to the territory is not to gather local information to improve institutional delivery; it is to reorganise the epistemological and political base from which intervention becomes thinkable, justifiable and transformable.

3.4 FROM TRANSFER TO THE CO-PRODUCTION OF PROBLEMS AND SOLUTIONS

Once the problem is redefined, the understanding of innovation also changes. The literature critical of diffusion shows that innovation cannot be conceived as a finished object that travels a linear trajectory between research, extension and adoption (Rist, 2009).

In contexts marked by social heterogeneity, ecological uncertainty and a plurality of knowledges, sustainable solutions tend to arise from processes of co-production, as described by Rist (2009), who discusses this displacement with clarity by opposing transfer and co-production of knowledge. It is argued that, in the face of complex and contested problems, the rigid separation between those who produce knowledge and those who apply it becomes unsustainable. Innovation comes to depend on social learning among farmers, researchers, extension agents and policymakers (Rist, 2009).

In consonance, Jasanoff offers the notion of co-production to think science, technology and social order as mutually constitutive dimensions (Jasanoff, 2004). Applied to the rural milieu, this perspective prevents separating technology from institutional arrangements, values, expectations and forms of collective coordination; and such a perspective is reinforced in the literature on agroecology, where, according to Cotrim (2017), the arenas of construction of agroecological knowledge show that extension professionalism shifts when the technician ceases to be a bearer of packages to act as a mediator, translator of languages and organiser of conditions of encounter (Cotrim, 2017).

The value of intervention comes to reside less in the intrinsic superiority of the offered solution and more in the capacity to sustain processes in which the community participates in the formulation of questions and in the practical validation of responses.

This change also appears in concrete methodological experiences, as described by Kersten and Ison (1998), who base themselves on active listening, interpretative cycles and dialogue meetings to overcome polarised debates between researchers and producers (Kersten; Ison, 1998).

The notion of territorial listening allows giving socio-technical density to these experiences, since it indicates that co-production does not derive solely from participatory methods, but from a reconfiguration of authority over what must be transformed. Without this reconfiguration, participation may be absorbed as a technique of adherence and, on the other hand, innovation gains territorial legitimacy by ceasing to respond only to external metrics of efficiency and coming to incorporate social temporalities, productive repertoires and local criteria of pertinence.

3.5 TERRITORIAL LISTENING AS AN EPISTEMOLOGICAL CATEGORY OF CONTEMPORARY RURAL EXTENSION

If diffusionist extension is organised around institutional supply, the extension that listens is organised around the shared construction of the problem. This difference is more than methodological, since it redefines the epistemology of extension action, the place of the technician and the meaning of public policy.

On the epistemological plane, the extension that listens departs from the recognition that the territory produces socially valid knowledge. This does not imply denying the importance of agrarian science or relativising technical criteria, but refusing its pretension of self-sufficiency to define priorities of intervention (Samborski *et al.*, 2017; Santos *et al.*, 2006; Sousa, 2015).

Technical truth remains relevant, but ceases to operate alone. It must be put into relation with norms, experiences, uses of space and collective expectations. In stronger terms, territorial listening displaces the extension epistemology from a logic of application to a logic of translation and co-production: knowledge does not leave the institution intact for the territory, but is recomposed at the interfaces where technical categories meet heterogeneous social rationalities (Deonti; Almeida, 2012; Jasanoff, 2004; Rist, 2009; Stroparo, 2025a).

On the methodological plane, territorial listening requires continued devices, and not merely inaugural consultations. The central point is not to open a channel for farmers to answer institutional questions, but to construct routines of immersion, observation, restitution, joint interpretation and revision of the course of action (Kersten; Ison, 1998; Marinho *et al.*, 2022). Listening, in this sense, is cumulative and reflexive. It informs the beginning of the

project, but also its permanent adaptation. Its most profound methodological requirement is to compel intervention to remain revisable in the face of the territory, instead of treating diagnosis as a rite of legitimation of previously stabilised decisions (Deponti; Almeida, 2012; Thiollent, 1984).

On the political plane, the extension that listens alters the position of the extension agent. The technician ceases to be the agent who carries ready-made responses and comes to act as a mediator of social interfaces, articulator of scales and facilitator of collective learning (Cotrim, 2017; Deponti; Almeida, 2012). This requires competences distinct from those associated with the old diffusionist professionalism: interpretation of conflicts, translation between languages, reading of territorial asymmetries and the capacity to sustain fragile pacts among diverse actors (Cotrim, 2017; Grícolo *et al.*, 2015). Professional authority does not disappear; it changes its foundation. Instead of deriving principally from the exclusive possession of legitimate knowledge, it comes to depend on the capacity to organise processes in which different knowledges may confront one another without any of them being defined in advance as the sole valid matrix of intervention (Cotrim, 2017; Samborski *et al.*, 2017; Torres-Rego, 2022; Stroparo; Floriani, 2022; 2024).

These transformations do not configure merely a change of procedures, but a broader alteration in the rationality of extension action. While the prescriptive paradigm concentrates on the institutional supply of previously defined solutions, the extension that listens displaces attention towards the processes by which problems, priorities and responses are constructed in the territories. In this movement, farmers cease to occupy only the position of recipients of policies and come to act as cognitive and political subjects of intervention; the extension agent ceases to be exclusively a diffuser of techniques to assume functions of mediation and translation; and innovation ceases to be evaluated solely by indicators of adoption to incorporate criteria of territorial pertinence, legitimacy and adaptive capacity (Stroparo; Floriani, 2026).

This displacement helps to reinterpret even the institutional landmarks of Brazilian ATER. The literature on PNATER shows that the formal adoption of participation, sustainability and agroecology opened space for another normative orientation (Diniz; Hespanhol, 2019). But the same literature evidences that such principles remain fragile when they do not materialise in institutional capacities of listening and mediation (Grícolo *et al.*, 2015; Zarnott *et al.*, 2017). The problem, therefore, is not only the text of the policy, but the persistence of organisational devices that continue treating the territory as a place of execution and not of problematisation.

Territorial listening, as an analytical category, helps to name precisely this gap. Its originality lies in uniting epistemological critique, territorial reading, theory of mediation and socio-technical approach within a single concept. It is not a matter of adding local sensitivity to extension, but of affirming that the legitimacy of extension action depends on its capacity to make the territory a space of co-production of the very terms of intervention. In synthesis, territorial listening designates the passage from an extension founded on the territorial application of solutions to an extension founded on the territorial production of public problems and socio-technical responses. Put differently, it simultaneously redefines what it is to know, what it is to intervene and what it is to innovate in the rural milieu.

Differently from active listening, predominantly directed at the quality of interaction between subjects, territorial listening refers to the institutional capacity to recognise the territory as a legitimate instance of formulation of the problems that orient public action. Its focus is not only on the manner in which one listens, but on the redistribution of authority over that which deserves to be heard.

7 FINAL CONSIDERATIONS

The analysis developed allows sustaining that the principal continuity between classical and contemporary forms of prescriptive extension does not lie only in the diffusion of technological packages, but in the extraterritorial concentration of problem definition. Even when the institutional discourse incorporates participation, dialogue and sustainability, the diffusionist logic may persist if listening remains subordinated to the validation of previously established agendas. The core of the problem, therefore, is not only methodological, but epistemological and political, because it concerns who possesses the authority to name reality, hierarchise urgencies and validate responses in the rural milieu.

It was to respond to this core that the concept of territorial listening was formulated as a category of contemporary rural extension.

The originality of the proposal resides in not treating listening as a moral attribute of the good extension agent nor as an accessory technique of participation. Its status is stronger: territorial listening designates a principle of reconstruction of the very rationality of extension, simultaneously redefining what it is to know, what it is to intervene and what it is to innovate in the rural milieu, by displacing extension from a logic of territorial application of solutions to a logic of territorial production of public problems and socio-technical responses.

The consequence of this formulation is decisive for the debate on socio-technical innovation in the rural milieu. More legitimate, inclusive and sustainable solutions tend to arise when farmers and communities participate not only in the execution or adaptation of

techniques, but in the very construction of the questions that organise the intervention. In this sense, the extension that listens does not represent a mere methodological variant of participatory extension, but expresses a new paradigm, in which the territorial mediation of knowledge becomes a condition for public action to cease operating upon the territories and come, effectively, to operate with them.

If this interpretation holds, the central fragility of many extension projects lies not in the absence of technologies or resources, but in the insufficiency of institutional mechanisms of listening capable of recognising rural territories as legitimate spaces of knowledge production, definition of priorities and co-production of solutions. It is in this displacement that, to a large extent, the possibility of an effectively contemporary rural extension is at stake.

In synthesis, territorial listening does not designate an additional procedure of consultation nor a technique of participatory improvement, but expresses a change in the very epistemological base of rural extension by recognising that the legitimacy of intervention depends on the capacity of the territories to participate in the definition of the problems that orient public action. Under this perspective, the passage from an extension founded on the territorial application of solutions to an extension founded on the territorial production of public problems constitutes one of the central conditions for the construction of effectively contextualised, legitimate and lasting socio-technical processes.

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SIGNIFICANT EXPERIENCES AT THE PAUL HARRIS SPECIAL EDUCATION CENTRE: A SCHOOL THAT DOES THINGS DIFFERENTLY AND MAKES A DIFFERENCE

EXPERIÊNCIAS SIGNIFICATIVAS NO CENTRO DE EDUCAÇÃO ESPECIAL PAUL HARRIS: UMA ESCOLA QUE FAZ DIFERENTE E FAZ A DIFERENÇA

EXPERIENCIAS SIGNIFICATIVAS EN EL CENTRO DE EDUCACIÓN ESPECIAL PAUL HARRIS: UNA ESCUELA QUE HACE DIFERENTE Y MARCA LA DIFERENCIA



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ABSTRACT

This report presents the formative experiences undertaken within the framework of the Institutional Programme for Teaching Initiation Scholarships (PIBID), carried out between November 2024 and June 2025 in a school in the municipality of Nova Iguaçu. The host school received 24 undergraduate students from Universidade Iguaçu, supervised by three teachers in a collaborative partnership. The project, entitled Literacy grounded in phonological awareness and the Boquinhos method, aimed to offer windows of opportunity for active, meaningful learning, full of senses and emotions, enabling knowledge to be constructed in accordance with the way the brain learns, that is, through phonological and visual pathways. It was grounded in scientifically proven theoretical concepts experienced in pedagogical practice at the host school and based on the assessment of children's thinking regarding nominal realism by Piaget (1998) and writing hypotheses according to Ferreira and Teberosky (1997) and Jardini (2014). The methodology adopted was qualitative, participatory and interdisciplinary, prioritising the co-authorship of the undergraduate students and the protagonism of the school community. This approach enabled the collective construction of pedagogical actions, adjusted to the real needs of the educational context, strengthening the articulation between university and school. The use of active methodologies and teamwork broadened the integration between theory and practice, fostering more consistent and reflective learning. The results obtained, assessed on the basis of the undergraduate students' opinions and reflective records, revealed high engagement, satisfaction and enthusiasm in the development of the activities. The experience contributed to consolidating an ethical, inclusive and empathetic pedagogical practice, valuing diverse forms of

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knowledge and promoting the integral development of learners, while reaffirming the social role of the teacher in training.

Keywords: Literacy. Inclusion. Training. Boquinhos Method. Phonological Awareness.

RESUMO

O presente relato apresenta as experiências formativas vivenciadas no âmbito do Programa Institucional de Bolsa de Iniciação à Docência (PIBID), realizadas entre novembro de 2024 e junho de 2025, em uma escola do município de Nova Iguaçu. A escola-campo recebeu 24 licenciandos da Universidade Iguaçu, supervisionados por três docentes em parceria colaborativa. O projeto, intitulado Alfabetização fundamentada na consciência fonológica e no método das boquinhos, teve como objetivo oferecer janelas de oportunidades para uma aprendizagem ativa, significativa, repleta de sentidos e emoções, permitindo que o conhecimento seja construído de acordo como o cérebro aprende, ou seja, pelas vias fonológicas e visuais e foi fundamentado em conceitos teóricos comprovados cientificamente e experienciados na prática pedagógica na escola-campo e fundamentado na avaliação do pensamento infantil sobre o realismo nominal de Piaget (1998) e hipóteses de escrita de acordo Ferreira e Teberosky (1997) e Jardini (2014). A metodologia adotada foi de caráter qualitativo, participante e interdisciplinar, priorizando a coautoria dos licenciandos e o protagonismo da comunidade escolar. Esse enfoque possibilitou a construção coletiva de ações pedagógicas, ajustadas às necessidades reais do contexto educacional, fortalecendo a articulação entre universidade e escola. O uso de metodologias ativas e o trabalho em equipe ampliaram a integração entre teoria e prática, favorecendo aprendizagens mais consistentes e reflexivas. Os resultados obtidos, avaliados a partir de pareceres e registros reflexivos dos licenciandos, evidenciaram elevado engajamento, satisfação e entusiasmo no desenvolvimento das atividades. A experiência contribuiu para consolidar uma prática pedagógica ética, inclusiva e empática, valorizando saberes diversos e promovendo o desenvolvimento integral dos educandos, ao mesmo tempo em que reafirma o papel social do professor em formação.

Palavras-chave: Alfabetização. Inclusão. Formação. Método das Boquinhos. Consciência Fonológica.

RESUMEN

El presente relato presenta las experiencias formativas vivenciadas en el ámbito del Programa Institucional de Beca de Iniciación a la Docencia (PIBID), realizadas entre noviembre de 2024 y junio de 2025, en una escuela del municipio de Nova Iguaçu. La escuela-campo recibió a 24 estudiantes de licenciatura de la Universidade Iguaçu, supervisados por tres docentes en colaboración. El proyecto, titulado Alfabetización fundamentada en la conciencia fonológica y en el método de las boquinhos, tuvo como objetivo ofrecer ventanas de oportunidades para un aprendizaje activo, significativo, repleto de sentidos y emociones, permitiendo que el conocimiento se construya de acuerdo con la forma en que el cerebro aprende, es decir, por las vías fonológicas y visuales, y se fundamentó en conceptos teóricos comprobados científicamente y experimentados en la práctica pedagógica en la escuela-campo, basándose en la evaluación del pensamiento infantil sobre el realismo nominal de Piaget (1998) y en las hipótesis de escritura según Ferreira y Teberosky (1997) y Jardini (2014). La metodología adoptada fue de carácter cualitativo, participativo e interdisciplinario, priorizando la coautoría de los estudiantes y el protagonismo de la comunidad escolar. Este enfoque posibilitó la construcción colectiva de acciones pedagógicas, ajustadas a las necesidades reales del contexto educativo, fortaleciendo la articulación entre universidad y escuela. El uso de metodologías activas y el trabajo en equipo ampliaron la integración entre teoría y práctica, favoreciendo aprendizajes más consistentes y reflexivos. Los resultados obtenidos, evaluados a partir de informes y

registros reflexivos de los estudiantes, evidenciaron un elevado compromiso, satisfacción y entusiasmo en el desarrollo de las actividades. La experiencia contribuyó a consolidar una práctica pedagógica ética, inclusiva y empática, valorando saberes diversos y promoviendo el desarrollo integral de los educandos, al mismo tiempo que reafirma el papel social del profesor en formación.

Palabras clave: Alfabetización. Inclusión. Formación. Método de las Boquinhás. Conciencia Fonológica.

1 INTRODUCTION

The Institutional Programme for Teaching Initiation Scholarships (PIBID) of the Ministry of Education of Brazil, managed by CAPES, is an initiative that links higher education to schools and to state and municipal systems and has, among its main objectives, to encourage the training of basic education teachers at higher education level, to strengthen the teaching degree courses of Higher Education Institutions and to enrich the theoretical-practical training of students enrolled in teaching degree courses.

From this perspective, a partnership was established between Universidade Iguazu (UNIG) and the Centro de Educação Especial Paul Harris, which began in 2023 the project Literacy Grounded in Phonological Awareness and the Boquinhas Method, consolidating the host school as a privileged space for innovative pedagogical practices. This project arose from the need to broaden teaching-learning opportunities for all pupils with significant delays in the literacy process, particularly in the post-pandemic period.

Since its implementation, this project was born with the mission of breaking decades of stagnation in an educational system that has historically neglected and condemned approaches and methodologies grounded in scientific evidence, this being a decisive step towards a true transformation in the training of future teachers who already assume the commitment to make a difference in the education of children, young people and adults. Such theoretical and practical knowledge, disseminated in the continuing education programmes offered at the host school and by the Casa do Professor of the Municipal Secretariat of Education to all teachers, trainees and students of the Pedagogy course, has been recognised as fundamental to teacher professional development, as well as to the possibility of significant changes in the way of teaching and learning and in the understanding of cognitive processes. By addressing themes such as cerebral plasticity, the role of emotions in learning, the importance of sleep and attentional processes, the aim is to promote reflections that connect scientific discoveries to the everyday pedagogical context. From this dimension, teachers are encouraged to become acquainted with this prodigious human machine called the 'brain' and to rethink their practices, adopting effective, evidence-based strategies that respect the functioning of the brain and favour pleasurable learning, full of senses, meanings and emotions, in addition to enabling the integral development of pupils.

From this perspective and given the relevance of mastering the stages of teaching-learning for successful literacy, the theoretical basis of this report is grounded in great scholars who have addressed important processes that permeate the assessment of children's thinking and nominal realism (Piaget, 2010); the psychogenesis of written language (Ferreiro e Teberosky, 1999); the hierarchy of the stages of phonological awareness (Silva,

2014, 2019). For the multisensory approach, the Boquinhas Method (JARDINI, 2014) was added to the literacy project. The studies and scientific research of the French mathematician and neuroscientist Dehaene (2012), author of the book *Reading in the Brain*, were also drawn upon, as he is dedicated to understanding the impact of reading on the brain and how it can optimise literacy methods, as well as enabling effective solutions, especially for children and people with dyslexia.

Under the guidance of such theoretical conceptions, it is understood that reading and writing not only transform brain structures but, above all, expand the mind, knowledge, the capacity for reflection, inquiry and critical thinking, also favouring creativity, the construction of new knowledge and cultural enrichment. In this sense, Soares (2003), in her article *Letramento e Escolarização*, summarises that literacy corresponds to the process by which one acquires the mastery of a code and of the skills necessary to use it in reading and writing, that is, the mastery of the technology – of the set of techniques – that enables the exercise of the art and science of writing (SOARES, 2003).

In line with this conception, the relevance of working with phonological awareness stands out, understood as the ability to reflect on the sound structure of the language, from the recognition of words, syllables, rhymes and alliterations to the phonemic level (SILVA, 2014). It is within this field that the Boquinhas Method is inserted, a phono-visuo-articulatory resource that combines auditory perception with orofacial movement and the image of the letter, favouring the multisensory learning of reading and writing, and is based on visible, tangible aspects that are easily recognised by any child (JARDINI; GOMES, 2009; JARDINI; SOUZA, 2006). By integrating these elements, the project sought not only to equip pupils to master the written code, but also to enhance their metalinguistic skills, promoting a more meaningful, pleasurable and inclusive literacy.

The understanding of the literacy process was profoundly transformed by the research of Ferreiro e Teberosky (1999) who, when investigating the construction of the writing system by children, identified different hypotheses that precede the acquisition of the conventional alphabetic system. In light of this understanding, it is recognised that the child already brings with them prior knowledge about writing and, therefore, it is up to the teacher to identify and diagnose at which stage they are, respecting their way of thinking and formulating hypotheses about the written code. This approach breaks with the mechanistic view of literacy and values the subject as active in the process of constructing knowledge.

From this standpoint, the literacy of pupils who present deficits in the reading and writing process, as well as those who present disabilities, are the greatest beneficiaries of this project. In addition to the teachers and students of the school community who receive

training, monitoring, exchange of materials and construction of pedagogical materials throughout the entire training process. In this sense, then, the project enabled us to share knowledge with all the teachers of the school space, of the Municipal Network of Nova Iguaçu and undergraduate students of the Pedagogy course of Universidade Iguaçu, offering opportunities for reflection on their pedagogical practice and on the importance of the teacher understanding, from the standpoint of neuroscience, the best paths and methods that lead pupils to achieve success in literacy, but in a pleasurable way, full of senses and meanings, respecting the way the brain learns, that is, through the sensory pathways.

Since the implementation of the Literacy Project, the entire school community has been benefiting. The methodology used favours respect for the needs of the pupils, as well as the possibility of beginning the literacy process in early childhood education in a playful, concrete way, through stimulation for cognitive maturation, skills and auditory/phonological awareness as proposed by Carla Silva.

The famous phrase of Lewis Carroll, in the classic *Alice in Wonderland*, "When you don't know where you want to go, any road will do", illustrates that the lack of a clear objective and destination makes any direction valid, leading to unexpected and sometimes negative and frustrating results. In the same way, the literacy process devoid of well-defined strategies and goals and marked by a lack of knowledge about the most appropriate paths to follow compromises the efficiency of teaching and the success of learning, both for the teacher and the pupil.

From this understanding, Dehaene (2012, p. 16) provokes a pertinent reflection by asking: "Can it be accepted that a cultured person knows better the functioning of their car or their computer than that of their own brain?". Such questioning reinforces the urgency of grounding pedagogical practices in scientific evidence about brain functioning, in order to guide more effective methodologies in literacy.

When one is unaware of how the brain learns, as well as of methodologies that bring security to the teaching-learning process, one runs the risk of making pupils subjects who begin the school year and end it without any change in their brain structures.

2 METHODOLOGY

The project Literacy Grounded in Phonological Awareness and the Boquinhas Method was constructed in a systematised and organised way according to the different stages of the literacy process, while also paying attention to the importance that no knowledge should be superimposed on another without the previous one being consolidated. The pupil in their

literacy process has bases that must be respected and that concern cognitive and psychomotor maturation and awareness of the aspects related to phonological awareness.

During this 2024/2025 period, 03 area supervising teachers and 24 PIBID participants from the Pedagogy course of Universidade Iguazu took part in the Institutional Programme for Teaching Initiation Scholarships (PIBID); they were allocated to 14 classes, of which children diagnosed with Down syndrome, autism, intellectual disability, ADHD, among others, are part.

Table 1

Number of participants in the PIBID of UNIG/CEE Paul Harris

Classes participating in PIBID	Classes	Participating pupils	Participating PIBID students
Early Childhood Education	2	34	4
1st year	2	33	4
2nd year	2	30	4
3rd year	2	30	4
4th year	2	29	4
5th year	1	20	1
6th year – special class	1	13	1
7th year – special class	2	27	2
TOTAL	14	216	24

Source: prepared by the authors.

The project was developed in the following stages:

- Initial and continuing training for students and the school community in face-to-face and online formats.
- Daily monitoring of the routine of the PIBID students through guidance, completion of forms and learning records.
- Construction of pedagogical materials by the PIBID students and supervisors.
- Assessment of Nominal Realist Thinking, according to Piaget.
- Assessment of the writing hypothesis.
- Stimulation of basic auditory skills.
- Stimulation and development of the stages of phonological awareness (auditory skills, word, sentence, syllable, rhyme and alliteration awareness).
- Stimulation of phoneme and phonemic awareness through the Boquinhas Method – a phono-visuo-articulatory methodology.

Figure 1

Training of the PIBID students and teachers of the Municipal Network of Nova Iguaçu



Source: prepared by the authors.

Figure 2

Assessment of the writing hypothesis: pupil at the pre-syllabic writing hypothesis and advancing towards the syllabic with sound value



Source: collection of the undergraduate students/PIBID students.

Figure 3

Phonological Awareness activities through the Boquinhas Method, a multisensory (phono-visuo-articulatory) methodology



Source: collection of the undergraduate students/PIBID students.

Figure 4

Word and sentence awareness – auditory awareness



Source: collection of the undergraduate students/PIBID students.

In the course of the project stages, the PIBID students were able to put into practice the theoretical foundations concerning diagnostic assessment, according to Piaget (2010) who, in accordance with his studies, holds that nominal realism is a characteristic of children's thinking by virtue of which the child expresses difficulty in dissociating the sign from the thing signified. This assessment makes it possible to understand and perceive the child's cognitive

maturity regarding writing. In this sense, the following question is posed: Which is the longest word? Joanelha (ladybird) or porco (pig)? Caminhão (lorry) or pé (foot)? Through their answers we observe the cognitive maturity in which the child will answer understanding that we are speaking about writing (the signifier) or about the attributes/characteristics (the signified). According to the logic of children's thinking, the child's answer is based on the attributes of the objects and not on the writing of the word. Some arguments used by the children were: porco (pig) is the longest word, because it is big. Joanelha (ladybird) is small because it has wings. The interventions were directed at leading the child to perceive the length of the word by counting the number of syllables, using objects such as bottle caps, modelling clay and the body as a strategy for understanding writing. Auditory skills should always be stimulated, seeking to associate that writing represents the sounds of speech (grapheme/phoneme).

During the second stage, an assessment was carried out regarding the writing hypothesis, according to the Psychogenesis of Writing. For the assessment, four (4) words were chosen in the following order: polysyllable, trisyllable, disyllable and monosyllable. After the drawing, the writing, reading and construction of a sentence, the analysis was carried out as proposed by Ferreiro (1999), who classifies them into four phases: pre-syllabic, syllabic with and without sound value, syllabic-alphabetic, alphabetic. We also added the iconic and scribbling phases of child development. The other pedagogical assessments and interventions are those pertinent to the stages of phonological awareness (word, sentence, syllable, rhyme, alliteration and phoneme awareness). The assessments and interventions address dynamic, playful, meaningful strategies and practices, in addition to the stimulation of auditory skills, based on the assumptions of Silva (2014; 2019). In a further stage, the Boquinhas Method of Jardini (2024) was added to the project owing to its scientific validity, and because it has its multisensory bases – phono-visuo-articulatory (phonic strategies: phoneme/sound) and visual (grapheme/letter) and articuleme (boquinhas).

By better understanding the methods and their applications in educational practice, we will be able to identify opportunities for improvement and to enhance the benefits of these approaches for the teaching-learning process, especially in the context of children's literacy.

3 RESULTS AND DISCUSSION

The assessment of pupils' learning, according to the Psychogenesis of writing, made it possible, over a period of two months, to verify the advances in the understanding and phonological awareness of writing, proving the efficacy and effectiveness of the methodology used. In this sense, having evidenced the paths towards a scientifically proven pedagogical

practice, it was decided to enable the undergraduate students of the Pedagogy course of Universidade Iguaçu (UNIG) to experience knowledge, theoretical and practical understanding through the Programme of Pedagogical Residency in 2022/2023 and the Programme for Teaching Initiation (PIBID) 2024/2025 at the host school Centro de Educação Especial Paul Harris. The teacher training of the undergraduate students of Universidade Iguaçu, in a regime of collaboration with the public school, enabled, in the field of teaching practice, the theoretical-practical training, providing skills and competencies for the professional exercise of the future teacher.

The results achieved by the Programme at the Centro de Educação Especial Paul Harris reveal that it was an experience of great scope and formative impact. The project involved 14 classes, with 216 pupils, from early childhood education to special classes of primary education, and counted on the direct participation of 24 Pedagogy undergraduate students, under the guidance of three supervisors. These figures evidence the dimension of the work and its relevance for the school and for initial teacher training.

The diversity of the classes – which included pupils with autism, Down syndrome, ADHD and intellectual disability – constituted fertile ground for applying literacy strategies based on phonological awareness and the Boquinhas Method. The work of the undergraduate students enabled the activities to be developed in a more personalised and inclusive way, respecting the rhythms of learning and ensuring that no pupil was left out of the process. This movement strengthens the distinctive character of the Centro Paul Harris, which consolidates itself as a school that does things differently, by adopting methodologies grounded in scientific evidence, and makes a difference, by offering concrete opportunities for development to all pupils.

The reflective records of the PIBID students indicated that the experience in heterogeneous classes broadened their understanding of literacy as a complex process, which requires careful diagnosis and pedagogical practices adjusted to the stages of cognitive maturation. Contact with real situations – such as the difficulties in nominal realism (Piaget, 2010) or the different levels of writing hypotheses (Ferreiro & Teberosky, 1999) – became an essential formative laboratory, uniting theory and practice.

Furthermore, the figures reinforce that the reach of the project was not restricted to one-off experiences: by involving more than two hundred pupils, the impacts were collective and multiplying. This is translated into the strengthening of the partnership between university and school, but also into the appreciation of a model of initial teacher training based on collaboration, interdisciplinarity and research in action.

The scope of the project demonstrates not only its pedagogical dimension, but also its social and political impact, by strengthening the integration between university and basic education. In the case of PIBID at the Centro de Educação Especial Paul Harris, the quantitative data reveal that the experience is not restricted to isolated actions, but constitutes itself as a public policy of training, with direct repercussions on the quality of teaching, on school inclusion and on the appreciation of the social role of the university. The data also reveal challenges, since the presence of a large number of classes with distinct characteristics requires diversified strategies, which, at times, generated difficulties for the undergraduate students, especially in the balance between time, resources and methodological adaptation. Even so, such challenges were converted into formative learning, reaffirming the importance of supervised practical experience in constructing knowledge in a collective and participatory way, which are fundamental requirements for students to be able to apprehend and articulate theory and practice.

4 FINAL CONSIDERATIONS

The experiences developed at the Centro de Educação Especial Paul Harris, within the framework of PIBID, confirm that pedagogical practices grounded in scientific evidence and combined with practical experience constitute a promising path to transform the literacy process and, at the same time, to strengthen initial teacher training. The presence of 24 undergraduate students, distributed across 14 classes and in direct contact with 216 pupils, demonstrated that the host school is configured as a space of innovation, reflection and social commitment.

The literacy project grounded in phonological awareness and the Boquinhas Method proved to be an inclusive and effective resource, especially in view of the specific needs of pupils with intellectual disability, autism, ADHD and Down syndrome. By adopting multisensory methodologies, the school showed that it is possible to overcome traditional practices centred on repetition and memorisation, valuing the child as an active subject in the construction of their own learning.

In the dimension of teacher training, PIBID enabled the undergraduate students to experience teaching as a reflective, ethical and collaborative practice, breaking with the distance between theory and practice. At the same time, it consolidated the role of the university in articulating with basic education, fulfilling its social function in accordance with Resolution CNE/CES nº 7/2018 on the curricularisation of extension.

Finally, the Centro Paul Harris proved to be more than a school: it became a space of collective transformation, where each pedagogical action is guided by the commitment to

inclusion, equity and the quality of learning. Thus, the meaning of the title of this report is reaffirmed: by assuming practices that break with the traditional and open up to the new, the Centro Paul Harris is a school that not only does things differently, but, above all, makes a difference in the lives of pupils, teachers and future teachers.

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COMPARATIVE ANALYSIS OF CONVENTIONAL CERVICAL CYTOLOGY AND COMPUTER-ASSISTED CYTOLOGY USING THE PICKCELLS SYSTEM

ANÁLISE COMPARATIVA DA CITOLOGIA CERVICAL CONVENCIONAL E ASSISTIDA POR COMPUTADOR ATRAVÉS DO SISTEMA PICKCELLS

ANÁLISIS COMPARATIVO DE LA CITOLOGÍA CERVICAL CONVENCIONAL Y ASISTIDA POR COMPUTADORA MEDIANTE EL SISTEMA PICKCELLS



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ABSTRACT

Cervical cancer is the fourth most common cancer in women worldwide and the third most prevalent type among women in Brazil. The mortality rate in Brazil, adjusted to the world population, was 5.33 deaths per 100,000 women in the latest triennium (2019-2022). Cervical cancer screening uses as a first line the traditional Papanicolaou test, visual inspection with acetic acid and Lugol's iodine, liquid-based cytology (LBC) and, in some cases, molecular tests for oncogenic HPV subtypes. Although advances have been made over the years, conventional screening procedures still suffer from diagnostic subjectivity, leading to false-positive and false-negative results. The present study aims to compare the main cytomorphological features that distinguish low-grade (LSIL) and high-grade (HSIL) squamous intraepithelial lesions, by means of images captured through optical microscopy and through the Pickcells automated system using the Pickcells Path scanner. To this end, five samples of each intraepithelial lesion, LSIL and HSIL, were selected. The criteria analysed, based on the Bethesda system, were the nuclear-cytoplasmic ratio, hyperchromasia, nuclear membrane contour and pleomorphism. The results obtained by the automated capture method were superior to the manual method, as they better highlighted the cytomorphological patterns characteristic of the lesions. Therefore, computer-assisted or automated cytology emerges as a perspective in the diagnosis of cervical carcinoma. The growing interest in the development of software and automated systems for cervical cancer screening aims to optimise analysis time, avoid ambiguity, eliminate false negatives and minimise the mortality rate.

Keywords: Conventional Cytology. Papanicolaou. Telecytology. Microscopy. Cervical Cytology.

RESUMO

O câncer do colo do útero é o quarto mais comum em mulheres em todo mundo e o terceiro tipo mais prevalente em mulheres no Brasil. A taxa de mortalidade no Brasil, ajustada pela população mundial, foi de 5.33 óbitos/100 mil mulheres, no último triênio (2019-2022). O

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rastreamento do câncer do colo do útero utiliza como primeira linha o exame de Papanicolau tradicional, inspeção visual com ácido acético e iodo de Lugol, citologia em meio líquido (LBC) e em alguns casos, teste moleculares para subtipos oncogênicos do HPV. Embora tenha havido avanços ao longo dos anos, os procedimentos de triagem convencionais ainda sofrem com as subjetividades do diagnóstico, ocasionando resultados falsos positivos e negativos. O presente trabalho tem como objetivo comparar as principais características citomorfológicas que distinguem as lesões intraepiteliais escamosas de baixo (LSIL) e alto grau (HSIL), por meio de imagens capturadas pela microscopia óptica e pelo sistema automatizado da Pickcells através do scanner Pickcells Path. Para este fim, foram selecionadas cinco amostras de cada lesão intraepitelial, LSIL e HSIL. Os critérios analisados, baseado no sistema Bethesda, foram a relação núcleo citoplasma, hipercromasia, contorno da membrana nuclear e pleomorfismo. Os resultados obtidos pelo método de captura automatizado foram superiores ao método manual, uma vez que evidenciaram melhor os padrões citomorfológicos característicos das lesões. Portanto, a citologia assistida por computador ou automatizada surge como uma perspectiva no diagnóstico do carcinoma cervical. O crescente interesse no desenvolvimento de softwares e sistemas automatizados para o rastreio do câncer do colo do útero visa otimizar o tempo de análise, evitar ambiguidade, zerar falsos negativos e minimizar a taxa de mortalidade.

Palavras-chave: Citologia Convencional. Papanicolau. Telecitologia. Microscopia. Citologia Cervical.

RESUMEN

El cáncer de cuello uterino es el cuarto más común en mujeres en todo el mundo y el tercer tipo más prevalente en mujeres en Brasil. La tasa de mortalidad en Brasil, ajustada por la población mundial, fue de 5.33 muertes por 100.000 mujeres en el último trienio (2019-2022). El cribado del cáncer de cuello uterino utiliza como primera línea la prueba de Papanicolaou tradicional, la inspección visual con ácido acético y yodo de Lugol, la citología en medio líquido (LBC) y, en algunos casos, pruebas moleculares para subtipos oncogénicos del VPH. Aunque ha habido avances a lo largo de los años, los procedimientos de cribado convencionales aún sufren las subjetividades del diagnóstico, ocasionando resultados falsos positivos y negativos. El presente trabajo tiene como objetivo comparar las principales características citomorfológicas que distinguen las lesiones intraepiteliales escamosas de bajo (LSIL) y alto grado (HSIL), por medio de imágenes capturadas mediante microscopía óptica y mediante el sistema automatizado de Pickcells a través del escáner Pickcells Path. Para ello, se seleccionaron cinco muestras de cada lesión intraepitelial, LSIL y HSIL. Los criterios analizados, basados en el sistema Bethesda, fueron la relación núcleo-citoplasma, la hipercromasia, el contorno de la membrana nuclear y el pleomorfismo. Los resultados obtenidos por el método de captura automatizado fueron superiores al método manual, ya que evidenciaron mejor los patrones citomorfológicos característicos de las lesiones. Por lo tanto, la citología asistida por computadora o automatizada surge como una perspectiva en el diagnóstico del carcinoma cervical. El creciente interés en el desarrollo de software y sistemas automatizados para el cribado del cáncer de cuello uterino busca optimizar el tiempo de análisis, evitar la ambigüedad, eliminar los falsos negativos y minimizar la tasa de mortalidad.

Palabras clave: Citología Convencional. Papanicolaou. Telecitología. Microscopía. Citología Cervical.

1 INTRODUCTION

Cervical cancer is the fourth most frequent neoplasm in women, excluding non-melanoma skin cancers, occupying the seventh position in the global ranking. In Brazil, the estimate for 2020 was 16,710 new cases, representing a rate of 7.5%, ranking only behind non-melanoma, breast, and colon and rectum cancers (INCA, 2020). This neoplasm is the leading cause of death among women in Latin America and the Caribbean (OPAS, 2021) (WCRF, 2021). In 2020 alone, about 604,000 women were diagnosed with cervical cancer worldwide and about 342,000 women died as a consequence of the disease (ASCO, 2022). In addition, the high incidence and mortality rates in underdeveloped and emerging countries reinforce cervical cancer as a public health problem, as it is directly linked to inequalities in income, gender and access to health services (WHO, 2021). The main cause of this neoplasm are high-risk human papillomaviruses, HPV 16 and 18, responsible for about 50% of cervical pre-cancers, which represent the primary cause of pre-cancerous or cancerous cervical lesions (IARC, 2021).

Although almost every type of cervical cancer is linked to HPV infection, more than 90% of patients eliminate the virus spontaneously, 6 to 12 months after contagion, owing to the immune response (Zhang *et al.*, 2020). However, a small percentage of these squamous intraepithelial lesions persist and may cause the establishment of neoplasia (Crosbie *et al.*, 2013). According to the third edition of the Bethesda System for Reporting Cervical Cytology (2015), there are four categories of squamous cell abnormalities: atypical squamous cells (ASC), low-grade squamous intraepithelial lesion (LSIL), high-grade squamous intraepithelial lesion (HSIL) and squamous cell carcinoma (Wang *et al.*, 2019).

In this context, LSIL is characterised by viral cytopathic changes. These changes include cytoplasmic clearing, nuclear enlargement, nuclear membrane irregularity, hyperchromasia, binucleation or multinucleation and anisonucleosis. The cells show squamous maturation and the nuclear-to-cytoplasmic ratio remains low (Chiaffarano, 2017). On the other hand, HSIL is a lesion of immature squamous cells, and the nuclear atypia (hyperchromasia, irregular chromatin distribution and irregularity of the membrane contour) is more severe than in LSIL (Alexander, 2019). Even though there is cytological distinction between LSIL and HSIL, there is a discrepancy rate of 10% to 15% among pathologists regarding the interpretations of squamous intraepithelial lesion on cervical cytology slides (Bethesda 2015).

Non-neoplastic conditions, including inflammation, atrophy with degeneration, hormonal factors, among others, can interfere with the result and produce cytomorphological changes that lead to questionable considerations regarding the designation of atypical

squamous cells of undetermined significance (ASC-US), atypical squamous cells cannot exclude a high-grade squamous intraepithelial lesion (ASC-H), (LSIL) and (HSIL) (Singh *et al.*, 2015). In addition, pre-cancerous lesions may be small and there are possible variations in location and quantity of diagnostic cells.

Therefore, to carry out screening by the conventional method, a screening lens of lower magnification is initially used, through the 10x objective lens. From the possible location of cytological abnormalities or the presence of aetiological agents, the lens is changed to 40x in order to visually detect these morphological changes and classify them through a high-power lens (Pankay, 2018). The time required for screening varies between 5 and 10 minutes, depending on the complexity of the sample, the inflammatory background and the appearance of cellular abnormalities according to the degree of the lesion. Owing to the long working hours, the number of samples per cytologist and possible interferences in the observations according to the degree of exhaustion of the professional, it is recommended that analysts do not work more than 7 hours a day and analyse a maximum of 70 samples per day (Pantanowitz *et al.*, 2009).

Therefore, it is known that conventional cervical cytology, through microscopic examinations for cytomorphological evaluation of cytological smears, is the most widely used method in defining thresholds for cervical cancer screening and treatment. The Papanicolaou test, also known as the cervicovaginal smear, is based on reading the smear and identifying the degree of loss of cytoplasmic maturation, the presence of abnormal mitotic figures and changes in the shape and size of the nucleus (Febrasgo, 2019). In addition to the Papanicolaou test, visual inspection with acetic acid and Lugol's iodine, liquid-based cytology and HPV testing are considered the main screening methods (WHO, 2019).

In the last decade, cervical cancer screening by traditional cytology has been questioned owing to variations in accuracy, since the specificity in detecting abnormal cells can generate ambiguities and possible biases of the human eye can interfere in the diagnostic process of the patient (Khan *et al.*, 2017). From this, and from the degree of demand and specificity required by conventional screening (a repetitive method requiring costly labour), automated screening emerges as an important tool in the early diagnosis of cervical cytological lesions (Conceição *et al.*, 2019).

It is known that computer-assisted cytology, or digital cytopathology, can expand comparative cytomorphological analysis, increasing sensitivity in the detection of cytomorphological patterns. It enables the visualisation of abnormalities in small squamous and glandular cells, known for the difficulty of detection and classification in the conventional

method, owing to cellular overlapping and the variety of backgrounds on the slide (Jusman *et al.*, 2014).

This technique can also increase the specificity of the examination, selecting only lesions corresponding to reproducible criteria. Furthermore, automated screening optimises analysis time, increases productivity by excluding normal samples, assists the cytologist's work, allows the selection of atypical images from a slide to be verified, increases the number of slides analysed, allows greater discussion in cases that are difficult to conclude, facilitates sample review in doubtful cases and reduces the physical space for permanent storage of results (Yu *et al.*, 2018).

Several methods for computer-assisted screening have been reported in the academic-scientific literature. These include automated screening with slide scoring, risk-based stratification of the presence of abnormalities, and location-guided search. The latter stands out for presenting greater potential in identifying abnormal cells (Bi *et al.*, 2019). The application of computer-assisted cytology to aid the diagnosis of cervical lesions is of great necessity for the expansion and standardisation of diagnostic analyses. In view of this, the present study aims to analyse, by comparison, the cytomorphological patterns of conventional and computer-assisted cervical cytology, using a cytopathological scanner.

2 MATERIALS AND METHODS

For the comparative study of the images, a total of ten cervical cytology slides were analysed, five of each smear lesion using the original Papanicolaou staining technique. The samples were provided by the Laboratório de Pesquisas Citológicas e Moleculares (LPCM) of the Universidade Federal de Pernambuco.

The slides were selected, reviewed and previously analysed by two cytopathologists from the LPCM; the double-blind methodology was used and they were interpreted based on the Bethesda classification system (2015). Five cases were characterised as low-grade squamous intraepithelial lesion (LSIL) and five cases as high-grade squamous intraepithelial lesion (HSIL).

With regard to the analyses, the application of the conventional method by conventional light microscopy was carried out with an optical microscope, model Nikon Eclipses E200MV R, using the 10x objective for screening the lesions and the 40x objective for characterising them. The computer-assisted analysis was carried out on an automated microscope from the company PickCells, a partner in the construction of this study, named PickCells Path, which performs the scanning of cytocervical slides and enables analyses with magnification of up to 40x.

The PickCells Path is a hardware and software solution, with end-to-end artificial intelligence algorithms, aimed at digital pathology. In this solution, the equipment moves through a pre-established function in order to scan the selected area of the slide, performing focus on the various fields and capturing the images automatically. The PickCells Path is an easy-to-handle piece of equipment, capable of performing readings with magnifications ranging between 10x (0.612 $\mu\text{m}/\text{pixel}$) and 40x (0.153 $\mu\text{m}/\text{pixel}$). Sample registration, slide reading, formation of the scanned image and the customised image visualisation tools are performed end-to-end by the automatic scanner. The equipment weighs 24 kg and has dimensions of 41x42x36 cm, and supports the analysis of up to six slides per tray.

After the slide captures, whether by the automated or conventional method, all images were analysed following the classification criteria for LSIL and HSIL recommended by the Bethesda system. The results were compared to enable the refined analysis of structures between the two methods.

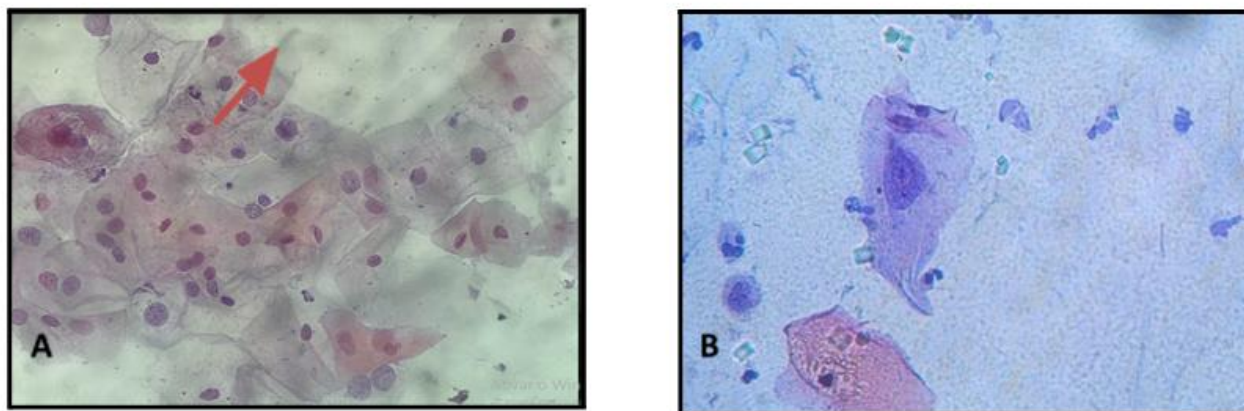
3 RESULTS

The main cytomorphological features used to compare the accuracy of the images captured by the conventional method (optical microscopy) and computer-assisted (Pickcells Path scanner) were nuclear morphology, nuclear-cytoplasmic ratio and cytoplasmic appearance.

In LSIL cells, the presence of a nucleolus was not evidenced in the images captured by the scanner. However, the sharpness of the images allowed chromocentres to be visualised. The chromocentres appear relatively smaller than the nucleoli, and poorly defined, with a basophilic staining pattern similar to chromatin (Figure 1A). This simple and important morphological finding is difficult to assess in the conventional method owing to the overlapping of granular heterochromatin (Figure 1B).

Figure 1

Presence of intermediate cells with characteristics of low-grade squamous intraepithelial lesion (LSIL). A: cell in monolayer, photograph taken by the conventional method; B: isolated cell, photograph taken with the PickCells scanner. Both photographs were captured using 40x magnification



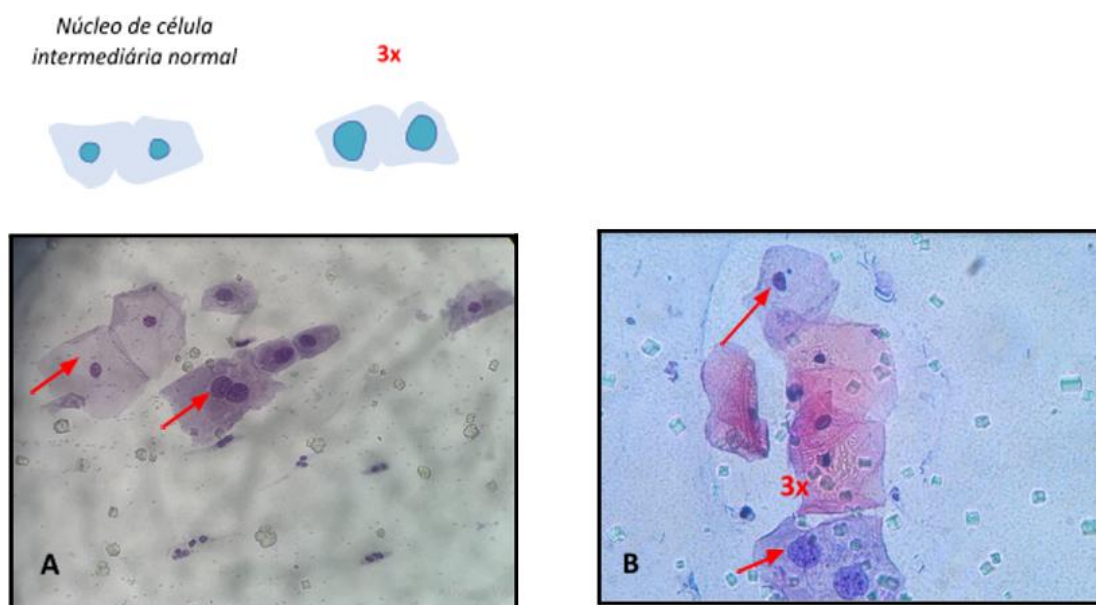
Source: prepared by the authors.

One of the most important diagnostic features used during the interpretation of epithelial cell abnormality is based on nuclear enlargement. In the conventional method it was possible to establish this nuclear/cytoplasmic ratio (Figure 2A). However, through the scanner of the Pickcells Path platform, we were able to identify with precision this difference in proportionality, with nuclear enlargement of more than three times the area of normal intermediate nuclei (Figure 2B), resulting in a low nuclear-cytoplasmic ratio, but slightly increased when compared with the normal intermediate cell.

Another relevant finding observed in the image obtained by the Pickcells Path scanner was the possibility of observing the nuclear membrane contour. In some cells the nuclear membrane presented an irregular appearance with indentations or 'notches' (Figure 2B). This detail was not easily identified in the conventional method (Figure 2A). There is also the possibility of focus adjustment, ruler and zoom quality.

Figure 2

Nuclear/cytoplasmic ratio in LSIL cells. (A) image obtained from the optical microscope, comparison of the size of the nucleus of the normal intermediate cell and of LSIL. Smooth nuclear membrane (arrowhead). (B) image obtained from the scanner, presence of indentation in the nuclear membrane

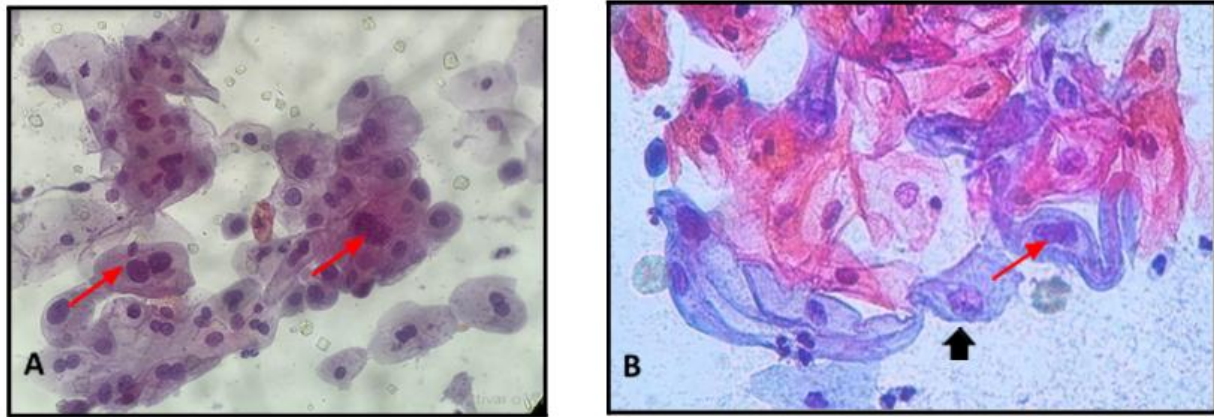


Source: prepared by the authors.

The cells presented a well-defined, dense 'mature' and abundant cytoplasm (Figure 3A). In some cells we identified clearly demarcated perinuclear cytoplasmic clearing (koilocytosis) with an irregular contour with focal angulation, which is characteristic of the HPV cytopathic effect (Figure 3B).

Figure 3

Presence of koilocytes in lesion cells classified as LSIL. (A) image obtained from the optical microscope, presence of a perinuclear halo without details in the contour. (B) image obtained from the scanner, presence of a perinuclear halo with details in the clearly demarcated irregular contour



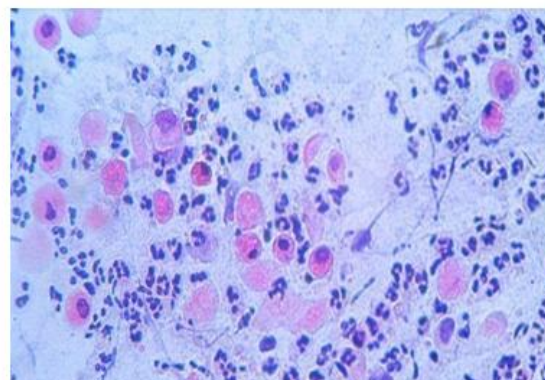
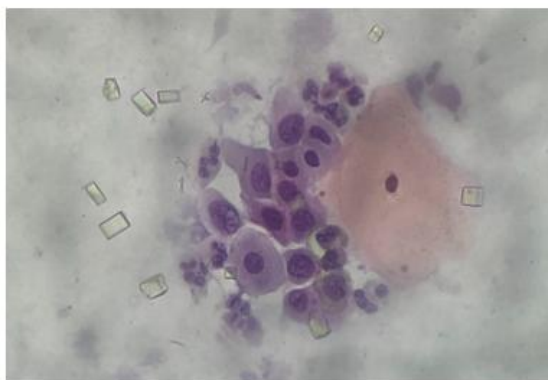
Source: prepared by the authors.

In cells of lesions classified as HSIL we evidenced marked nuclear pleomorphism (Figure 4A). Although this finding is relevant for the HSIL classification, by the conventional method we were not able to easily identify other features such as the presence of nuclear grooves.

On the other hand, the images obtained by the Pickcells Path scanner made it possible to clearly identify squamous cells with the appearance of immature 'basal' cells (Figure 4B). This is a relevant fact because it generates much subjectivity during conventional analysis and induces the false-negative diagnosis for HSIL.

Figure 4

Lesion cells classified as HSIL. (Left) image obtained from the optical microscope, presence of pleomorphism and anisonucleosis. (Right) image obtained from the scanner, presence of atypical mature squamous cells, with the appearance of immature cells and eosinophilic cytoplasm



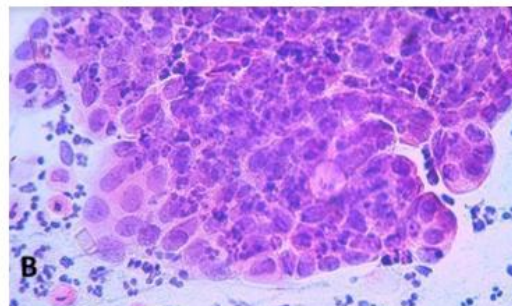
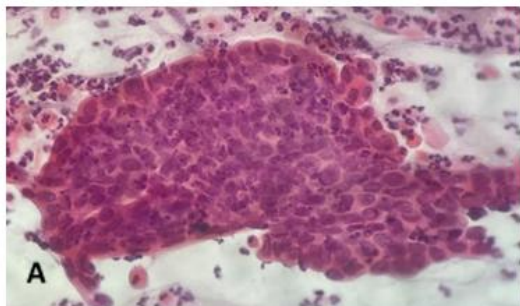
Source: prepared by the authors.

The images captured by the Pickcells automated microscope presented satisfactory results in relation to the sensitivity and specificity of the criteria established for the analysis of abnormal alterations in cellular morphology. Analysing a syncytial grouping by both methods, it is possible to perceive that in the photographs obtained by the scanner the appearance of the chromatin is more evident, varying from slightly to coarsely granular and distributed homogeneously (Figure 5B).

Furthermore, in the conventional method the cytoplasm has a more cloudy or indistinct appearance, without delimitation of the cytoplasmic borders between cells (Figure 5A). In the scanner, on the other hand, we identified delicate, immature, or densely metaplastic cytoplasm, with defined borders between cells (Figure 5B).

Figure 5

Syncytial grouping. (A) image obtained from the optical microscope, poorly delimited cytoplasm, with no space between cells. (B) image obtained from the scanner, immature cytoplasm, alteration in the size and shape of the nucleus



Source: prepared by the authors.

4 DISCUSSION

Establishing the evaluation criteria for cervical cytology is of paramount importance for accurate diagnosis. However, depending on the qualitative and quantitative limitations of the sample, some equivocal morphological features suggestive of squamous cell abnormality may lead to a questionable diagnosis.

Analyses from the IARC website demonstrate the disparity among cytopathologists in the interpretation of cervicovaginal smear samples. In an HSIL sample, suggested by the authors, 200 professionals classified it as atypical squamous cells (ASC-H), approximately 110 as LSIL, 80 as ASC-US, 20 as only inflammation and 185 as HSIL. These data reinforce the need to use more sensitive and specific tools in diagnosis.

Many researchers believe that telecytology can contribute to minimising mistaken interpretations. According to the study carried out by Greon and collaborators (2017), digital cytology demonstrated agreement rates between 81% and 90% of intermodality among three observers who had sufficient training in digital cytopathology. The authors identified that the most observed incompatibility in all the data was between ASC-US/atypical squamous cells, cannot exclude high-grade squamous intraepithelial lesion (ASC-H) and LSIL, which may indicate low reproducibility of the recognition of koilocytosis or koilocytotic atypia, followed by the discrepancy between LSIL and HSIL, suggesting difficulty in recognising varied levels of cellular atypia.

According to the Bethesda 2015 system, unequivocal features of LSIL with definitive interpretation that most generate subjectivity in samples are: drying of the sample, presence of navicular cells, inflammatory changes, degeneration process, folic acid deficiency, repair,

radiation and atrophy. The presence of hyperchromasia, unchanged cytoplasm, binucleation and smooth nuclear membrane reflects difficulty in the differential diagnosis between ASC-US and LSIL (Chivukula *et al.*, 2006; Chiaffarano *et al.*, 2017).

In general, hyperchromatic nuclei with coarse chromatin in LSIL cells do not have nucleoli. However, this simple and important morphological feature may be difficult to assess owing to cellular overlapping. With the advent of assisted cytopathology, these peculiarities are already possible to visualise.

One of the main and easily identifiable cytomorphological features of LSIL is koilocytosis. In the images obtained from the scanner, koilocytes show altered nuclei with clearly delineated perinuclear cytoplasmic clearing with an irregular contour. This result is important to rule out aspects that mimic LSIL, such as pseudokoilocytosis. These details were not clearly evidenced under light microscopy. Koilocytes are mature squamous cells with recognisable nuclear and cytoplasmic changes. They derive their characteristic morphology largely owing to productive HPV infection. They are characterised by perinuclear cavitation, binucleation, nuclear hyperchromasia and nuclear enlargement (Alrajjal *et al.*, 2021).

Many studies question the diagnostic accuracy of digital cytology. However, the cytological literature relates about 93% to 86% accuracy of the diagnosis of cervical cytology (House *et al.*, 2013). In this study it is proven that, in fact, the cytomorphological features are more highlighted in the images obtained by the scanner, thus enabling the evaluation of the peculiarities of each type of lesion.

According to Vodovnik *et al.*, 2016, what makes telecytology attractive is (1) time: the images analysed by light microscopy took on average 5.5 times longer to be screened; (2) sample quality: clarity and richness of detail; (3) diagnostic confidence and agreement: the images analysed use the software's AI as a reference; (4) increased productivity of pathologists; (5) real-time information sharing; (6) review of results by more than one cytopathologist; (7) reduction of physical space: storage of digital files.

Furthermore, the analysis and interpretation of samples through digital cytology allows for the description of the samples. It is worth highlighting that the Pickcells automated system already has a post-analysis tool that simulates a tape measure to measure the size of the nucleus. This is of great value for establishing the nuclear/cytoplasmic ratio and characterising the type of lesion according to the criteria.

Owing to the resolution capacity of the scanner, it was possible to easily identify significant nuclear atypias characteristic of HSIL. The morphological changes observed in HSILs are similar to, but distinct from, those of LSIL. HSIL cells have a high nuclear-cytoplasmic volume ratio, greater nuclear hyperchromasia, complex nuclear membrane

irregularities and marked variation in nuclear size (Alrajjal *et al.*, 2021). Irregularities in the nuclei of HSIL cells are one of the most reliable diagnostic features of this lesion and reflect profound disarrangements in cellular function and genetic instability. Hyperchromasia and nuclear enlargement are often striking in HSIL and, like koilocytosis, reflect the increase in DNA content (Hassanpour & Dehghane, 2017).

The variation in the size and shape of the nucleus (anisonucleosis) is a manifestation of genetic instability, aneuploidy and cell-to-cell variation in the karyotype. The amount of cytoplasm reflects the degree of maturation of squamous cells and is an important feature in the classification of squamous intraepithelial lesions as LSIL or HSIL. With LSIL, the cytoplasm is abundant, equivalent to that observed in intermediate squamous cells. With HSIL, the cytoplasm is less abundant, tending towards scarcity, equivalent to that observed in basal and parabasal cells. The accuracy of the image pattern obtained by the scanner made it possible to exclude common problematic patterns of HSIL that include cases of squamous metaplasia, presence of histiocytes, pseudoparakeratosis, grouping of basal and parabasal cells in atrophy (Neto, 2020).

The growing interest in the development of automated diagnostic systems for cervical cancer screening is closely related to the difficulties encountered in characterising the lesion. The automated detection of abnormal changes in cellular morphology brings greater accuracy and reduces the subjectivities of diagnosis. Furthermore, automated cytology can detect a greater number of potentially ill patients, minimise false negatives, without losing sensitivity and specificity, and assist in manual diagnosis (Bertram *et al.*, 2022).

However, digital cytology has been somewhat limited compared to whole-slide imaging. One of the main reasons is the inability to focus on cytology materials, such as thick smears, obscured material, three-dimensional cell groups, overlapping cells and even smears that extend beyond the coverslip of a glass slide. Cost is also important to evaluate when considering these two technologies. The automated system requires a microscope, a whole-slide scanner, camera, computer and software, whereas light microscopy requires a microscope, computer and camera. Maintenance costs are relevant for both solutions (Hanna *et al.*, 2017).

5 CONCLUSION

For years, the conventional Papanicolaou smear cytology technique has been used as an effective screening test for cervical cancer. However, the limited sensitivity and specificity of cervical cytology in revealing cervical cancer, at its early stage, and its precursors has been questioned. Moreover, it is seen that although there are specific

distinctions and characterisations between LSIL and HSIL, there is a discrepancy rate of 10% to 15% among pathologists, leading to erroneous results and to repercussions in the prognosis and treatment of these patients.

With regard to conventional analysis, the increase in false-positive and false-negative results is increasingly seen, which cannot be totally prevented and tends to appear more frequently owing to human interferences in the process, such as variations between the human eye, differences in analysis among professionals, difficulties with the increase in the work routine, among others. In view of this, the pursuit for the development of computer-assisted solutions for cervical cancer screening becomes increasingly common, since it enables the increase in sensitivity in the detection of cytomorphological pattern, allowing the visualisation and classification of abnormalities, in addition to generating possibilities of diagnostic sharing and counter-evidence of the lesions through images. Therefore, the technique increases the specificity of the examination, since it allows the selection of specific areas, optimises analysis time, increases productivity and reduces the storage of material (Yu *et al.*, 2018).

In view of this, this study aimed to carry out a comparative analysis between the visualisation of cervical cytological slides, by means of two visualisation methods, the conventional and the automated, in order to evaluate the possibility of cytomorphological characterisation and definition through each technique. For this, 10 slides were selected from the Laboratório de Pesquisas Citológicas e Moleculares (LPCM), which were analysed by independent cytopathologists, by means of a double-blind, being characterised through the Bethesda system as 5 LSIL and 5 HSIL. The conventional analysis was carried out by means of an optical light microscope (Nikon Eclipses E200MV R) and the automatic analysis carried out by an automated scanner from PickCells (PickCells Path), a partner company of the study. The cytomorphological features analysed were nuclear morphology, nuclear-cytoplasmic ratio and cytoplasmic appearance.

In this study, it is seen that the conventional method limited the analysis of some patterns such as nuclear pleomorphisms in HSIL lesions, the presence of nuclear grooves in them, the difficulty of delimiting the nuclear membrane contour, in addition to generating images with cytoplasm of a more indistinct appearance, without delimitation of the borders between cells. However, this method made it possible to establish the nuclear-cytoplasmic ratio, important for the characterisation and determination of the lesions.

Regarding the images obtained by the scanner, they generally brought satisfactory results with the possibility of detailing and a refinement process in the image, with only a few negative points, such as the difficulty of evidencing nucleoli in LSIL slides. On the other hand,

the images obtained by the PickCells Path scanner proved to be detailed and capable of demonstrating the main structures such as the chromocentres, the difference in comparative proportionality between cells in the nuclear-cytoplasmic ratio, the nuclear membrane contour, cells with the appearance of immature 'basal' cells, among others. Therefore, in general, the images generated by the PickCells Path scanner presented satisfactory results among the established cytomorphological criteria.

If we analyse the comparison between the visualisations of both methods, we have that the images generated by the scanner highlight the appearance of the chromatin, the proportionality of the nuclear-cytoplasmic ratio and the definitions in the cellular cytoplasm. The images analysed by optical microscopy, on the other hand, appear with the cytoplasm indistinct and poorly delimited, in addition to it not being possible to delimit the proportion of the nuclear-cytoplasmic ratio nor the presence of koilocytosis through them. Therefore, owing to the resolution capacity of the automated method, it was possible to identify the significant nuclear atypias in the analysed groupings.

Therefore, it is concluded that the Pickcells automated system offers a viable solution for screening and interpreting cervical cytology samples owing to the structural detailing of cells, through zoom, placement and image quality. It is interesting to highlight that the use of this technology depends on cytologists who are well trained in the use of this system, so that reports are not issued in a way that invalidates the sample results. In addition to this, comparative trials should be carried out and limitations such as cost and analysis time should be raised in subsequent studies.

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REFLECTIONS ON COGNITIVE LIBERTY: BETWEEN LAW, ETHICS, AND NEUROTECHNOLOGIES

REFLEXÕES SOBRE A LIBERDADE COGNITIVA: ENTRE O DIREITO, A ÉTICA E AS NEUROTECNOLOGIAS

REFLEXIONES SOBRE LA LIBERTAD COGNITIVA: ENTRE EL DERECHO, LA ÉTICA Y LAS NEUROTECNOLOGÍAS



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ABSTRACT

Considering the advances in Neuroscience and artificial intelligence, along with the growth of Neurotechnologies, the general objective of this work is to understand the ethical implications of new technologies in Neuroscience—particularly those involving neuromodulation and brain imaging—within a time frame of the last twenty years, in order to capture the technological period in which these technologies expanded. The study is developed through bibliographic research, and the method of approach adopted is the deductive one, starting from the general international context of the growth of Neuroscience in contemporary times and addressing the advances in brain imaging and neuromodulation technologies, so as to arrive at the particular question, namely: can such technologies bring about ethical impacts on consciousness, personal identity, autonomy, privacy, and responsibility? Three specific objectives are proposed: first, to present the concept of Neuroscience and some of the new brain technologies, especially imaging and neuromodulation; next, the second idea is to point out the possible ethical implications of the technologies set out in chapter two. Finally, the third objective seeks, based on the ethical implications indicated, to reflect, at least minimally, on the possibility of neurorights and concepts pertaining to the legal sphere, such as consciousness, personal identity, autonomy, privacy, and criminal responsibility. This study is relevant and justifiable because, on a broad scale, it discusses the ethical and legal limits of technological intervention in the human mind. In conclusion, for the authors presented, the technologies described may impact consciousness, personal identity, autonomy, privacy, and responsibility. This is because, according to these authors, there may be a risk of neural surveillance and editing influencing individual and collective decisions. Thus, one possible path is to reflect on the new ethical and regulatory frameworks now emerging with respect to neurorights.

Keywords: Law. Neurorights. Neurotechnologies. Ethics. Liberty.

RESUMO

Considerando os avanços da Neurociência, da inteligência artificial e o incremento das Neurotecnologias o objetivo geral deste trabalho é compreender as implicações éticas das novas tecnologias em Neurociência, especialmente, as de neuromodulação e de imagem cerebral com recorte temporal dos últimos vinte anos para garantir o intervalo tecnológico de expansão dessas tecnologias. Será desenvolvido por meio de pesquisa bibliográfica e o método de abordagem utilizado será o dedutivo partindo-se do contexto geral internacional de incremento da Neurociência, na contemporaneidade, abordando os avanços das tecnologias de imagem cerebral e de neuromodulação de modo a se chegar à questão particular, qual seja: tais tecnologias podem trazer impactos éticos para consciência, identidade pessoal,

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autonomia, privacidade e responsabilidade? Tencionam-se três objetivos específicos, quais sejam, primeiro: apresentar o conceito de Neurociência e algumas das novas tecnologias cerebrais, especialmente de imagem e neuromodulação; na sequência, a segunda ideia é: apontar as possíveis implicações éticas das tecnologias explicitadas no capítulo dois. Por fim, no terceiro objetivo pretende-se a partir das implicações éticas indicadas refletir, minimamente, acerca da possibilidade dos neurodireitos e conceitos afetos à esfera jurídica como consciência, identidade pessoal, autonomia, privacidade e responsabilidade penal. Esse estudo é relevante e justificável, pois, em escala ampla, discute os limites éticos e jurídicos da intervenção da tecnologia na mente humana. Ao final, conclui-se que para os autores apresentados as tecnologias explicitadas podem impactar na consciência, identidade pessoal, autonomia, privacidade e responsabilidade. Isto porque para os últimos pode haver risco de vigilância e edição neural influenciando as decisões individuais e coletivas. Assim, um caminho possível é refletir acerca dos novos marcos éticos e regulatórios que estão despontando sobre os neurodireitos.

Palavras-chave: Direito. Neurodireitos. Neurotecnologias. Ética. Liberdade.

RESUMEN

Considerando los avances de la Neurociencia y de la inteligencia artificial, así como el incremento de las Neurotecnologías, el objetivo general de este trabajo es comprender las implicaciones éticas de las nuevas tecnologías en Neurociencia, especialmente las de neuromodulación y de imagen cerebral, con un recorte temporal de los últimos veinte años, a fin de abarcar el intervalo tecnológico de expansión de dichas tecnologías. Se desarrollará mediante investigación bibliográfica, y el método de abordaje utilizado será el deductivo, partiendo del contexto general internacional de incremento de la Neurociencia en la contemporaneidad, abordando los avances de las tecnologías de imagen cerebral y de neuromodulación, de modo que se llegue a la cuestión particular, a saber: ¿pueden tales tecnologías traer impactos éticos para la conciencia, la identidad personal, la autonomía, la privacidad y la responsabilidad? Se proponen tres objetivos específicos, a saber: primero, presentar el concepto de Neurociencia y algunas de las nuevas tecnologías cerebrales, especialmente las de imagen y neuromodulación; a continuación, la segunda idea es señalar las posibles implicaciones éticas de las tecnologías expuestas en el capítulo dos. Por último, en el tercer objetivo se pretende, a partir de las implicaciones éticas indicadas, reflexionar, mínimamente, acerca de la posibilidad de los neuroderechos y de conceptos vinculados a la esfera jurídica, como la conciencia, la identidad personal, la autonomía, la privacidad y la responsabilidad penal. Este estudio es relevante y justificable, pues, a gran escala, discute los límites éticos y jurídicos de la intervención de la tecnología en la mente humana. Al final, se concluye que, para los autores presentados, las tecnologías expuestas pueden impactar en la conciencia, la identidad personal, la autonomía, la privacidad y la responsabilidad. Esto se debe a que, para estos últimos, puede haber riesgo de vigilancia y edición neural que influya en las decisiones individuales y colectivas. Así, un camino posible es reflexionar acerca de los nuevos marcos éticos y regulatorios que están surgiendo sobre los neuroderechos.

Palabras clave: Derecho. Neuroderechos. Neurotecnologías. Ética. Libertad.

1 INTRODUCTION

Considering the advances in Neuroscience, artificial intelligence and the growth of Neurotechnologies (NTs), the general objective of this work is to understand the ethical implications of neurotechnologies, especially those of neuromodulation and brain imaging, since these two have been the most widespread and present satisfactory results for the diagnosis and treatment of neurological and psychiatric diseases. As for the time frame, considering the advances in brain technologies, the technological interval should be the last twenty years in order to ensure scientific currency.

It will be developed through bibliographic research, and the method of approach adopted will be the deductive one, starting from the general international context of the growth of Neuroscience in contemporary times, addressing the advances in brain imaging and neuromodulation technologies so as to arrive at the particular question, namely: can such technologies bring ethical impacts to consciousness, personal identity, autonomy, privacy, and responsibility?

Furthermore, as to the methodology, during the preparation of this work the author declares that she used the Gemini tool (version 2.5 Flash, by Google) in December 2025 to assist with translation, textual fluidity, and formatting in accordance with the standards of the ABNT (Brazilian Association of Technical Standards). All generated content was rigorously reviewed and validated by the author, who assumes responsibility for all published content.

As for the research sources, the intention is to use academic articles, the Universal Declaration on Bioethics and Human Rights, as well as documents from international bodies such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Organization for Economic Co-operation and Development (OECD). In this field, given the interdisciplinary nature of the issue, it should be emphasized that the perspective will not be only ethical or legal; mention is also made of the sciences related to the theme, such as Medicine, Psychology, Engineering, and Information Technology.

In the development, three specific objectives are intended, namely, first: to present the concept of Neuroscience and some of the new brain technologies, especially imaging and neuromodulation; next, the second idea is: to point out the possible ethical implications of the technologies set out in chapter two. Finally, in the third objective the aim is, based on the indicated ethical implications, to reflect, at least minimally, on the possibility of neurorights and concepts pertaining to the legal sphere, such as consciousness, personal identity, autonomy, privacy, and criminal responsibility.

In light of the above, the following topics are proposed: introduction; chapter two: Neuroscience and new brain technologies; chapter three: ethical implications of imaging and

neuromodulation technologies and chapter four: new dimensions in the concepts of consciousness, identity, autonomy, privacy, and responsibility; and, finally, the final considerations.

The hypothesis proposed in this work is that, yes, the new technologies addressed in the text may impact the contours of the concepts pertaining to the legal prism, namely: consciousness, personal identity, autonomy, privacy, and responsibility, since there is the possibility of mapping neural data which, taken together, are capable of helping to identify patterns of thought, thus allowing certain actions to be individually or collectively encouraged or discouraged depending on the controller's objective. It is in this field that scholars have addressed mental privacy, cognitive liberty, and the protection of neural data as specific rights: neurorights, a concept to be explored in the development of this work.

Above all, studies to be presented in due course in this research indicate that emotions and behaviors can be altered by new technologies, generating a personality distinct from the one the individual had before clinical intervention. This matters, above all, because of the expansion of access to such technologies and the possibility of their use in non-therapeutic or non-clinical contexts. In this sense, an individual who undergoes a change in personality may suffer a loss of identity, affecting self-perception and engendering an estrangement from oneself, impacting personal identity and autonomy.

In light of the above, this study is relevant and justifiable because, in general, it discusses the ethical limits and legal impacts of neurotechnological intervention in the human mind, as well as projecting a discussion for the coming years that must traverse the idea of neurorights, and of what will be considered cognitive enhancement and what will be therapeutic.

In the end, it is concluded that the technologies set out may impact the ethical-legal sphere of consciousness, personal identity, autonomy, privacy, and responsibility. This is because there is a risk of neural surveillance and editing influencing individual and collective decisions. In this sphere, the path is to reflect on the new ethical and regulatory frameworks that are emerging regarding the contemporary limits of Neuroscience and brain technologies.

2 NEUROSCIENCE AND NEW BRAIN TECHNOLOGIES

In January 2024, The New York Times announced brain implants: *“Neuralink Implanted a Device in a Patient’s Brain, Elon Musk Says: The billionaire Said his company’s first product, called Telepathy, would let a person control a phone or computer “just by thinking”* .(Mac, 2024).

The Neuralink experiment prompted social reflections, especially because, according to Waisberg, there was low transparency regarding the way the experiment was carried out, the long-term effects of the implant, as well as the surgical risks, since the procedure of implanting or removing a chip from the brain is invasive. The use of this type of device also prompted reflections regarding the control and privacy of neural data which could be extracted from this device, in addition to stimulating discussions about the ethical limits of clinical or non-clinical interventions in brain activity. (Waisberg, 2024)

In addition, the last author highlights the need for robust informed consent, as well as the possibility that these technologies may deepen social inequalities, since it cannot be determined whether they would be available to everyone or whether they would be marketed at a high price as cognitive enhancement, besides engendering debate about users' consent, clarifying that such techniques are invasive and require the migration of wires within brain tissue. (Waisberg, 2024)

In January 2025, The Lancet Neurology announced the most relevant research in Neuroscience of 2024, among them the advances in blood biomarkers and brain omics. This important record made explicit the ability to detect proteins associated with Alzheimer's early, constituting an advance in the diagnosis of this disease, surpassing imaging exams and biopsies. (Fu; Ip, 2025).

One of the phenomena most studied by Neuroscience is the search for an understanding of consciousness; questions such as where it derives from remain a subject of investigation and disagreement among neuroscientists. Studies suggest that it would result from the integration of distinct parts of the brain; Koch stated in 2025 that it derives from the posterior cortex. This study monitored the brains of 256 participants in real time using brain-measurement techniques. Above all, it attempted to demonstrate how information is unified and integrated by the brain, generating new contours for studies in artificial intelligence and biology (Karel, 2025).

The contemporary structure and understanding of the concept of consciousness is a source of debate, especially due to the development of artificial intelligence (AI) systems. This is because the consciousness or non-consciousness of AIs has been frequently questioned. Topics such as “The artificial intelligence robot that became a millionaire with cryptocurrencies and now wants to be recognized as a person” pervade the news. (Walker, 2025)

The discussion is latent considering the growing impact of language models capable of simulating human conversations fluently. That is, can this new way of “conversing” (simulating?) be regarded as consciousness, since it stems from an artificial process? It is

still early to answer this and other questions raised throughout this text; however, there is a certain urgency in defining markers to detect where consciousness arises. Such identification makes it possible to develop treatments for neurological diseases, to identify vegetative states or coma, in addition to speculating on a central question of contemporary times, which ponders whether AI machines can develop consciousness and subjectivity.

In this panorama, in May 2025, BBC NEWS asked “*Can artificial intelligence already be conscious? What scientists say*”. The text reflects that recent research investigates consciousness in experiments such as the dream machine. According to Ghosh, experts believe that some AI systems may soon become conscious as they acquire greater processing and sensory information. On the other hand, there are those who argue that true consciousness could arise only in living systems characterized by biological life. (Ghosh, 2025)

Another study investigated the definition of the moment of death and raised social debates. In 2024, G1 announced “A neuroscientist's discoveries about what happens in the brain while we die”. (Rodriguez, 2024). Through the use of electroencephalography (EEG), this research helped to explore the idea that perhaps the brain does not stop immediately after cardiac arrest. The authors indicate findings suggesting that the brain enters a kind of survival mode when deprived of oxygen, thus closing communication with the exterior to focus on internal processes of the body itself, intensely synchronizing the neural networks.

Although it is an incomplete study, it may give rise to ethical reflections, for example, regarding the moment of switching off devices in order to avoid residual suffering, prompting future revisions about the criteria of brain death, in addition to impacting the techniques and the appropriate moment for resuscitating people. (Xu *et al.* , 2023)

The question of consciousness set out above sets neuroscientists against one another, but it was raised to reveal the debate within the Neurosciences and how it is interconnected with new technologies, such as those of brain imaging or artificial intelligence. After presenting these contemporary debates about the new technologies that are connected to the multidisciplinary field in question, the next point is to define what can be understood as Neuroscience and as Neurotechnologies.

Neuroscience is a multidisciplinary field that studies the nervous system; thus, areas such as Medicine, Biology, Psychology, Engineering, and Philosophy come together to think about the brain and how it generates thoughts, actions, emotions, memories, languages, chemical reactions, the functioning of organs, among other possibilities. Especially in recent years, the use of computing and AI to try to replicate human brain processes is frequent, and for this reason Neuroscience, which is able to unite these various branches of knowledge,

gains prominence, since it also seeks to understand brain functioning. Below, some concepts relevant to the present research will be explored, and for this reason some direct quotations are necessary.

In summary, considering the importance of Neuroscience for the present work, it is clarified how this field of knowledge can operate

Neuroscience is the field of knowledge that studies the nervous system, including the structure, function, development, genetics, evolution, and pathology of the nervous system and the brain. It combines several disciplines, including biology, psychology, chemistry, physics, mathematics, and computer science, to understand how the nervous system functions at the molecular, cellular, systemic, and behavioral levels. Neuroscientists employ a variety of techniques, such as neuroimaging (such as functional magnetic resonance imaging and electroencephalography), animal studies (such as rodents and non-human primates), molecular and cellular biology techniques, computational modeling, and clinical studies in humans to investigate questions related to the brain and the nervous system. The goals of Neuroscience are vast and include understanding the neural basis of behavior, emotions, cognition, memory, learning, perception, sleep, movement, and much more. In addition, Neuroscience has applications in a wide range of areas, including medicine (to understand and treat neurological and psychiatric disorders), artificial intelligence (to develop intelligent systems inspired by the brain), and even in fields such as economics and law (to understand how the brain influences human behavior). (Santos and Coutinho, 2024)

Still in the conceptual sphere, Neuroscience, when forming a multidisciplinary trio with artificial intelligence and engineering, may seek to translate biological signals into digital commands and has, in this case, been called Neurotechnology. Although there is no consensus regarding the concept of neurotechnologies, use is made of the extensive paragraph from the National Data Protection Authority (ANPD) on the subject, as it connects various international bodies in a synthetic manner

The OECD (2019, p. 6, our translation) defines neurotechnologies as the “[...] devices and procedures used to access, monitor, investigate, assess, manipulate and/or emulate the structure and function of the neural systems of natural persons”. The same conceptualization is adopted by the International Bioethics Committee of UNESCO (2022, p. 13), which incorporates into its definition of neurotechnologies the actions of devices and procedures on the neural systems of animals. Neurotechnologies refer to a range of methods and tools for interacting with the brain and the nervous system, with this interaction occurring either passively, to monitor brain activity, or actively, to alter it (Andorno, 2023, p. 12). In turn, the ICO (2023, p. 8, our translation) conceptualizes neurotechnologies as the “[...] consumer, business, and health devices and procedures, both invasive and non-invasive, that directly record and process neurodata for the purpose of collecting data, controlling interfaces or devices, or modulating neural activity”. The UN (2024, p. 2, our translation), through a report of the Advisory Committee of the Human Rights Council, highlights that “the term ‘neurotechnologies’ encompasses a range of devices and systems that interact with the central nervous system by electrical, magnetic, optogenetic² and other means”.

Such devices may assist in understanding how the brain functions, or may also intervene in the processes of the nervous system aiming to recover functions or enhance capacities (UN, 2024, p. 2). For Bertoni and Ienca (2024, p. 2), neurotechnology should be understood as a broad concept that encompasses devices, tools, systems, and algorithms aimed at understanding, influencing, accessing, monitoring, assessing, emulating, simulating, or modulating the structure, activity, and functioning of the nervous systems of human beings and other animals. This definition, when compared with the others above, presents greater specificity and coverage regarding the purpose of the use of neurotechnologies, as well as incorporating algorithms as an integral part of the spectrum of neurotechnologies. **Neurotechnologies enable the establishment of a direct connection between the brain and devices external to it, and this gives them a singularity that requires attention to the ethical-legal repercussions, since this type of connection can permit interventions in brain activities** (UN, 2024, p. 2) (Brazil, 2025, emphasis added)

In the last decade, the rapid advance of these three fields of knowledge has been able to redefine, reinterpret, and manipulate the way the human brain operates. The ability to observe neural activity in real time has allowed an increasingly precise understanding of human brain activity and, therefore, of the individual and collective behaviors of this group.

Simultaneously with this scientific development, other methods of brain analysis have also drawn attention: neuromodulation. The latter makes it possible to directly access and render controllable the dynamics of the brain system and, for this reason, has been applied in clinical and experimental research. Having introduced the concepts and considering the direct interventional capacity in the brain, added to the growth of external devices (chips, glasses, helmets, and headphones) that connect to that organ through brain-machine interfaces, in this work it was chosen to focus in particular on the most emerging modulation and image-monitoring neurotechnologies: the so-called neuroimaging and neuromodulation, also touching on brain-machine interfaces, which will be set out in chapter three, below.

2.1 BRAIN IMAGING TECHNOLOGIES (NEUROIMAGING) AND NEUROMODULATION

Neurotechnology for this work can be understood as the set of techniques and tools that unites distinct sciences and makes it possible to record, investigate, and alter an activity, and may serve distinct applications which will be illustrated in this chapter. The OECD highlighted neurotechnologies as one of the emerging technologies, along with synthetic biology and artificial intelligence. This is because, according to the same organization, they “are characterised by rapid development and uncertainty in trajectory and impact.” (OECD, 2025)

In November 2025, UOL ran the headline “Neurotechnology revolution turns science fiction into reality”. According to the text, direct communication with the brain, aiming at the

restoration of movement in paralyzed individuals and turning thoughts into words, are capabilities of neurotechnologies. The rise of this type of instrument can be frightening, especially because it raises ethical questions regarding the use and social impact of these technologies. (Agence France-Presse, 2025).

The growth of neuroimaging changed the way scientists study the human brain; this observation procedure makes it possible to see the complex functioning of this organ. Next, neuroimaging and its associated technique, namely the brain-computer interface (BCI), will be explored.

2.1.2 Brain imaging technologies and brain-computer interfaces

Among the neuroimaging technologies, functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and positron emission tomography (PET) stand out². Each one has its particularities: fMRI can map areas of brain activity that correlate with motor, sensory, or cognitive functions; it is a kind of photograph of the structure; PET, on the other hand, can assist in visualizing other processes, for example neurochemical ones, that is, it assesses brain metabolic activity based on the emission of positrons, while EEG can serve to capture brain electrical activity synchronously, through electrodes on the scalp, monitoring the electrical activity so that the brain rhythms recorded in graphs can be assessed.

The combination of these technologies is capable of serving to understand cognitive, emotional, and behavioral neural bases. In this way, it supports research in important areas, such as psychiatry and neurology, in addition to contributing to clinical diagnosis. Below, these three neuroimaging techniques will be highlighted. Beginning with fMRI, Meneses *et al* point out that

Functional magnetic resonance imaging (fMRI) is a new technique capable of detecting small changes in blood flow and oxygenation of brain tissues where neuronal activation occurs. Its use in the pre-surgical evaluation of patients with epilepsy who have temporal mesial sclerosis is currently under evaluation at some neurology centers. The main objective is to find the best activation paradigm in the evaluation of language and memory functions, aiming to replace the Wada test, widely used nowadays. ((Meneses *et al* ., 2004)

As for EEG, in this technique electrodes are placed on the scalp and the captured signals are converted into digital data; it monitors the electrical activity so that the brain rhythms recorded in graphs can be assessed. The analysis of such rhythms makes it possible

² Positron Emission Tomography, from the English

to identify excessive electrical impulses which point to a predisposition to epilepsy or a seizure, for example. According to Zhang *et al* it “is a non-invasive measurement method for brain activity. Owing to its safety, high resolution, and hypersensitivity to dynamic changes in brain neural signals, EEG has aroused much interest in scientific research and medical fields.”. (Zhang *et al* ., 2023)

PET, in turn, can identify tiny tumors that the techniques previously presented here would not be able to. It also makes it possible to assess the response to chemotherapy treatment, for example, whether the cells remain diseased, in metastasis, or whether they have stopped progressing. Because it is a non-invasive technique, capable of analyzing the whole body in a single exam, it is widely used for the diagnosis of diseases, especially in oncological, cardiovascular, and neurological practice, as Vaquero and Kinahan point out

Of all the tomographic molecular imaging modalities, positron emission tomography (PET) probably offers more translational possibilities than any other modality, owing to its combination of sensitivity and quantitative accuracy. PET is a non-invasive imaging modality that provides physiological information through the injection of radioactive compounds (radiotracers), detection of the radiation, and reconstruction of the radiotracer distribution. PET imaging has evolved from an imaging modality used for research into a standard component of diagnosis and staging in oncology; it is also used for specific neurological and cardiovascular indications. This is due to the clinically useful information it provides about the function and state of tissues and organs, through the use of radiolabeled molecular imaging agents. (Vaquero and Kinahan, 2015)

However, the sophistication of these brain imaging technologies, as well as the capacity for technical intervention in brain circuits, whether for therapeutic purposes or not, concerns scholars, and it is precisely for this reason that this work is justified by the risks and ethical implications associated with the uncertain and historically unprecedented use of this type of instrument. The integration of these techniques of brain reading and assessment, associated with the possibility of modulating emotions and therefore also of altering behaviors, reveals the relevance of the contemporary debates pertaining to the subject of this subchapter.

The possibility of influencing behavioral dynamics in real time gave rise to research highlighting the implications of the techniques under discussion. In this sphere, brain-computer interfaces have also become more sophisticated so as to be able to operate simultaneously with these techniques. Below, what these interfaces are is set out, and then some risks associated with the technologies in question are mentioned.

BCIs emerge to establish communication between brain activity recorded by neuroimaging and translated into external devices. “Brain-computer interfaces (BCIs) use

brain signals to gather information about the user's intentions. To do this, BCIs rely on a recording stage that measures brain activity and translates the information into interpretable electrical signals.”, explain Nicolas-Alonso and Gomez-Gil. (Nicolas-Alonso and Gomez-Gil, 2012)

According to Burwell, Sample, and Racine, there is no consensus on the definition of the brain-computer interface, but it is an area undergoing abrupt development in Neuroscience. The authors state that

(...) there are some elements on which researchers and scholars commonly agree. These crucial elements are the capacity of a BCI to (1) detect brain activity directly, (2) provide feedback in real or near-real time, (3) classify brain activity, and (4) provide feedback to the user reflecting whether he/she has successfully reached a goal [10]. Similar to most authors [9], we consider a BCI to be a device that detects brain signals conveying intention and translates them into machine-executable output [11]. In other words, it is a direct connection “between living neuronal tissue and artificial devices that establishes a non-muscular communication pathway between a computer and a brain” [12]. BCIs have potential of great significance in patients' daily lives [13]. For example, BCIs ³can be used as “spellers” for individuals who have no other way to communicate [12, 14,15,16,17,18], can give people who are locked in or paralyzed some control over their environment [12, 15, 19,20,21,22,23,24], and may be able to assist rehabilitation after spinal cord injury via artificial stimulation of the muscles [11, 24], among other potential applications. (Burwell, Sample, and Racine, 2017)

To clarify the function of BCIs, Nicolas-Alonso and Gomez-Gil add

A brain-computer interface (BCI) is a hardware and software communication system that allows brain activity alone to control computers or external devices. The immediate goal of BCI research is to provide communication capabilities to people with severe disabilities, such as total paralysis or those “locked in” by neuromuscular disorders such as amyotrophic lateral sclerosis, brainstem stroke, or spinal cord injury. (Nicolas-Alonso and Gomez-Gil, 2012)

Still, in the same sphere, classic examples of BCIs are: the p300Speller, although its accuracy is considered low according to Nicolas-Alonso and Gomez-Gil, is an EEG-based communication system which was designed to allow severely paralyzed patients to select letters on a screen using only brain activity in order to communicate with other people (Nicolas-Alonso and Gomez-Gil, 2012).

Another example is neuroprostheses, which can control robotic upper limbs via mental activity. There are also specific systems that can control wheelchairs or drones through brain activity. Although they are not the object of this work, it is worth highlighting how motor

³From the English, Brain Computer Interface (BCI), or brain-computer interface

neuroprostheses work, with a view to understanding their real potential to promote health and well-being in certain individuals

(...) there is a method of activating neural structures by means of an FES system ⁴that facilitates a specific movement and allows its use in the real context in which people live; these are the so-called Neuroprostheses or Motor Neuroprostheses (MN) (MENDES *et al.* , 2020). A neuroprosthesis for grasping, for example, is an FES system that restores the ability to grasp objects; and there are neuroprostheses with diverse objectives, for standing, walking, reaching, etc. (MARQUEZ-CHIN; POPOVIC, 2020). MNs are devices developed to assist in the restoration of motor functions and in performing a lost function. They **have an interface with the nervous system stimulating muscles, nerves, spinal cord, or brain and are being used daily to increase the activities and participation of people with impairments** (COLLINGER *et al.* , 2013). The MN has a typical architecture composed of **sensors to capture the user's command intention or automatic control of the stimulation, a control unit (controller), a stimulator, and electrodes that distribute the stimulation; making possible an autonomous operation** during the performance of functional activities, (...) (GIL-CASTILLO *et al.* , 2020; MARQUEZ-CHIN; POPOVIC, 2020; MENDES *et al.* , 2020). (Lopes, 2021)

The potential of BCIs is promising, especially for use in communication and in paralysis, in addition to use for entertainment. In this sphere, according to the OECD, they can promote health and well-being for individuals with disabilities or in rehabilitation. (García and Winickoff, 2022)

Thus, it does not seem appropriate to halt this type of instrument given its capacity to promote well-being, but neither can the risks associated with the sophistication of some technologies be neglected, as will be explored in the chapter that follows. The point here was to present the functioning of the classic BCIs. Having outlined the panorama, concept, and application of BCIs, which can operate together with neuroimaging, the focus turns below to the other technology with the capacity to intervene directly in the brain: neuromodulation.

2.1.3 Neuromodulation

Still in the context of Neuroscience and the technologies related to it with human interventional capacity, neuromodulation also stands out, because it can be key to direct intervention in neural circuits. According to Pancholi *et al.* , 2025, it is a “medical field focused on altering nervous activity by means of specific stimuli.” (Pancholi *et al.* , 2025).

The technology in question is not to be confused with neuroimaging or with BCIs; the former have the capacity to observe brain activity, while the interfaces translate such movement to some external apparatus. On the other hand, neuromodulation acts on

⁴ Functional Electrical Stimulation (FES)

neurodynamics, that is, an electrical, chemical, magnetic, or optical stimulus is applied directly to a specific area of the brain aiming to alter the connection between neurons. Such an alteration may be transient or permanent depending on the stimulation.

Marder explains that neuromodulation can modify intrinsic properties of neurons, that is, it reconfigures neuronal circuits and this can significantly alter the output of these circuits. This matters because, according to the author, all nervous systems are subject to being neuromodulated, and depending on the intensity and frequency they can build functional circuits that will give rise to a particular behavior. She reflects on whether the action of the modulator can be robust and predictable considering the variability among animals or among neurons, further questioning whether the procedure is reliable across individuals since each one may have a nervous system with different patterns. (Marder, 2012)

In a study on long-term neuromodulation, Palacios-Filardo and Mellor indicated that neuromodulators such as dopamine, serotonin, and noradrenaline, when released, can facilitate long-term synaptic plasticity, that is, the brain could reprogram and modify its connections between neurons in response to a given stimulus. In this way, a connection could be strengthened or weakened. (Palacios-Filardo and Mellor, 2018)

Through long-term potentiation (LTP), in which after repeated and intense stimulation the connection between neurons can be strengthened. Whereas, in long-term depression (LTD) the connection between certain synapses may be little used, discouraged, and therefore weakened, since the brain, to avoid its saturation, discards the irrelevant. The authors indicated evidence that each of these neuromodulators can trigger mechanisms that facilitate long-term potentiation or depression (Palacios-Filardo and Mellor, 2018).

Although the complexity of the subject is indisputable, an attempt is made to translate in a simple way how potentiation works: when a new skill is stimulated repeatedly, a neuron sends a signal to the others; such repetition strengthens learning so that later, in the future, even a weak stimulus produces a quick response, and for this reason it is not necessary, for example, to relearn how to ride a bicycle: once the connection has been learned and already potentiated, it is recognized.

And it is precisely this capacity to affect behavioral mechanisms through repetition, creating memory and the learning of behaviors, that is concerning and justifies this chapter of the work; above all, if used in a non-therapeutic context, it may have uncertain ethical consequences.

The foundation of this technology is the idea that many psychiatric or neurological disorders derive from some activity, whether electrical or chemical, but one that is considered abnormal within a specific neural circuit. (Pancholi *et al* ., 2025).

To clarify, Neudorfer *et al* explain that in an experiment of deep brain stimulation to treat essential tremor disease, the focus was on the thymic targets within a particular nucleus and a particular brain area. Next, they discussed the historical bases for the selection of these targets. The point is that they integrated imaging and electrophysiological techniques to improve the precision of the chosen target and presented indications that such accuracy in target targeting yielded a superior result in suppressing the tremors of that disease. (Neudorfer *et al* ., 2024)

Pancholi *et al* . also explain that within this medical field there are: invasive techniques, for example, deep brain stimulation, responsive neurostimulation, vagus nerve stimulation, and spinal cord stimulation; and non-invasive ones which can be, also by way of example, transcranial magnetic stimulation, focused ultrasound, and transcranial direct current stimulation. (Pancholi *et al* ., 2025). However, Krishna and Fasano explain that this list of techniques is not exhaustive and is constantly expanding, and they mention that “treatments such as deep brain stimulation (DBS) are now adopted in almost every country worldwide, with a steady growth in the number of implanted patients.” (Krishna and Fasano, 2024)

There is no intention to detail how neuromodulation can act on neurological and psychiatric disorders, but the point is that among the most cited non-invasive procedures are transcranial magnetic stimulation and electrical stimulation, techniques which offer precise adjustments in stimulation and have provided greater safety when compared to invasive approaches, since they avoid surgery, as Camacho-Conde *et al* .:

Brain stimulation involves the passage of electrical currents to brain cells in the cortical and subcortical area to modulate brain functions and is carried out by two methods: non-invasive and invasive. Technological advances have contributed to the development of various techniques within both categories (see Box 1) (S). Non-invasive stimulation is carried out using two distinct techniques: transcranial magnetic stimulation (TMS), introduced in 1985, 2 (2) and transcranial electrostimulation (TES), in clinical use since 1801. 3 (s) However, currently, the most widely used form of TMS is repetitive TMS (rTMS) and of TES is transcranial direct current stimulation (tDCS). Non-invasive brain stimulation techniques use electrical currents applied directly through magnetic fields or electrodes on the patients' scalp to stimulate cortical brain cells, while invasive stimulation, such as deep brain stimulation (DBS), involves the passage of electrical currents to brain cells in the subcortical area through electrodes implanted surgically more deeply in the brain. Unlike the invasive ones, the non-invasive methods do not require anesthesia and surgical operation and, therefore, are preferred over invasive methods. In the last decade, the use of these brain stimulation methods has not only increased substantially but has also expanded to a wide variety of brain disorders, including schizophrenia, major depressive disorder, anxiety disorders, and cognitive dysfunctions. (Camacho-Conde *et al* ., 2022)

Neuromodulation has been explored in the treatment of psychiatric disorders such as addictions, obsessive-compulsive disorder (OCD), and depression; although for the most part these are experimental treatments, there are already neuromodulation options approved by the FDA for the latter two disorders, as Ranjan, Mahoney, and Rezai clarify

With insights from the neurocircuitry of psychiatric disorders and extensive experience of neuromodulation with deep brain stimulation (DBS) in movement disorders, DBS is increasingly being considered a modulator of the neural network in psychiatric disorders. (...). The FDA (United States Food and Drug Administration) has approved the indication of DBS for psychiatric disorders. Medically refractory depression, addiction, and other psychiatric disorders are being explored for DBS neuromodulation. Studies evaluating DBS for psychiatric disorders are promising but lack larger, controlled studies. (...). We also present a brief review of MR-guided Focused Ultrasound (MRgFUS), a new form of neurosurgical neuromodulation, which can reach deep subcortical structures similar to DBS, but in a non-invasive way. The early experiences of neurosurgical neuromodulatory therapies, including MRgFUS neuromodulation, are encouraging in psychiatric disorders; however, they remain investigational. Currently, DBS and VNS are the only neurosurgical neuromodulation options approved by the FDA in appropriately selected cases of OCD and depression, respectively. (Ranjan, Mahoney, and Rezai, 2024)

Furthermore, regarding the possibilities of using neurostimulation, Gouveia *et al* point out its use in the treatment of drug-resistant epilepsy and indicate vagus nerve stimulation and responsive neurostimulation as procedures that have been used. Although the former is the most accessible, including being approved by the FDA for children, the responsive route and deep brain stimulation have been promising in cases of drug-resistant seizures, since there was a reduction in the frequency of seizures, according to those authors. (Gouveia *et al* ., 2024).

In summary, what was intended to be demonstrated in subsection 2.1 is that the integration of neuroimaging neurotechnologies, added to the possibility of neuromodulation practices, has driven clinical and therapeutic practices as well as emerging research. Such a combination of techniques allows researchers to monitor in real time the changes in brain activity, deepening the understanding of how the brain system functions. From such knowledge it is possible to identify markers that guide early diagnosis or the personalization of medical treatments. For this reason, neurotechnologies are promising in correlating Neuroscience, technologies, and clinical practices. However, these experiments come accompanied by many ethical questions, since they act directly on human cognition with the capacity for behavioral modification, whether for its enhancement or its weakening.

Finally, despite all these benefits in the treatment and diagnosis of the most diverse diseases, the impacts of the use of these technologies are still uncertain, especially

considering, for example, that the latest technologies, such as *smartphones* became popular in less than two decades. Thus, concerned with this rapid advance, scholars from distinct fields of knowledge are concerned with these implications, a subject which will be addressed next, especially from an ethical point of view.

3 ETHICAL IMPLICATIONS OF IMAGING AND NEUROMODULATION TECHNOLOGIES

The contribution of Neuroscience to the research, treatment, and diagnosis of some diseases is incontestable, as was attempted to be shown in chapter two. Specifically, when one considers the number of people who are affected by psychiatric disorders and who do not respond to treatment, which increases the risk of suicide and death of these individuals. Such an occurrence reveals that techniques such as neuromodulation seem socially desirable.

Likewise, the hypothesis that individuals with movement disorders such as Parkinson's and essential tremor, or even the possibility of paralyzed individuals regaining some control over their activities, are ideals that are highly esteemed, as Whitten argues

The sophisticated methods of Neuroscience — including molecular genetics, structural and functional neuroimaging, animal models, and experimental tasks that simulate real-world behaviors in human research — have provided important insights into typical functioning and neurobehavioral disorders. Translational Neuroscience seeks to use this knowledge to improve the human condition, developing and refining interventions for these disorders. (Whitten, 2012)

Mental disorders, according to Camacho-Conde *et al* are prevalent in all communities, and depressive disorders rank third in the global burden of disease. Even in middle- and high-income countries, with suicide being the third leading cause of death among groups aged 15 to 24 and the fourth among those aged 18 to 65, and according to the authors, since medications and other treatments are not always effective, there has been in recent years interest in the application of brain stimulation to try to address this issue. (Camacho-Conde *et al* ., 2022)

The idea of alleviating the suffering of these distinct groups is esteemed; however, such a contemporary context, which brings together various fields of knowledge, distinct technologies, and techniques added to artificial intelligence, and which seems quite promising in the diagnosis and treatment of diseases, has gained momentum, especially because of the speed with which some methods can advance, and gives rise to disquiet both socially and academically. The intriguing social debate can be visited through the New York Times article of November 2025, the article “*Big Tech Wants Direct Access to Our Brains:As*

neural implant technology and A.I. advance at breakneck speeds, do we need a new set of rights to protect our most intimate data — our minds?” (Kinstler, 2025)

The title of the aforementioned text was highlighted here because it serves to evidence the social clamor on the issue, since it also addresses the access that technology companies may have to what goes on in the intimacy of human minds and how this could be used by large companies to track emotions and energy levels, and warns of the risk of mind control and behavioral manipulation that could be employed on a large scale. Hypothetically, it reflects on what could happen if an EEG signal were capable of identifying political ideology, lying, or sexual orientation. (Kinstler, 2025)

Neural data can offer unparalleled insight into the workings of the human mind. B.C.I.s are already frighteningly powerful: Using artificial intelligence, scientists have used B.C.I.s to decode “imagined speech,” constructing words and sentences from neural data; to recreate mental images (a process known as brain-to-image decoding); and to trace emotions and energy levels. B.C.I.s have allowed people with locked-in syndrome, who cannot move or speak, to communicate with their families and caregivers and even play video games. Scientists have experimented with using neural data from fM.R.I. imaging and EEG signals to detect sexual orientation, political ideology and deception, to name just a few examples. (Kinstler, 2025)

The political and scientific community has also reflected on mental privacy, control of neural data, cognitive liberty, and related rights, which, on a broad scale, aim to protect mental integrity, and which the literature has termed *neurorights*. In 2024, the European Parliament addressed the subject of the ethical challenges regarding the protection of mental privacy in the area of Neuroscience, whose title also deserves mention because *it touches on part of the reflection intended to be proposed in this chapter The protection of mental privacy in the area of neuroscience: Societal, legal and ethical challenges*. (Maia de Oliveira Wood *et al* ., 2024)

The last text states that, as a result of this debate and to generate social visibility for the subject, the *Neurorights Foundation* was created, which aims to discuss and assess the proposal of *neurorights*. The authors question the bases that underpin such rights and make explicit that caution is necessary on the subject, especially because it centers its theory on the idea that the human self originates in the brain (although this explanation is quite accepted by the academy), which can reduce the human to neural data, engendering a certain objectification of the individual. (Maia de Oliveira Wood *et al* ., 2024)

This last perspective is also debated because it touches on the notion of the human dignity of the vulnerable (for example, patients in a coma or with cognitive disabilities), a value that is central in civilized societies. According to the text, although the consequences are

unintentional, and the social and collateral effects are not fully known, one of the greatest issues concerns the pressure for the individual to adapt to performance levels that are attainable only through invasive interventions. (Maia de Oliveira Wood *et al.* , 2024)

The text concludes with a critical analysis, mentioning that converting moral rights into legal rights deserves reflection and that they do not always need to be enshrined in positive law. That is, it questions whether more legislation is necessary or whether existing rights would be sufficient to protect concepts such as freedom of thought, mental integrity, and privacy. The authors consider whether these traditional rights, with a historical basis, could also protect against manipulations in the cognitive sphere. (Maia de Oliveira Wood *et al.* , 2024)

The concern with the neural sphere occurs, according to Chneiweiss, because neurotechnologies are not yet manufactured commercially on a large scale, but this should not take long, and he warns that it may be too late to act. (Chneiweiss, 2025)

Below, some ethical risks will be clarified which are also connected to technical risks of these neurotechnologies. Marder explains that it is complicated to answer the question of whether the action of a modulator is predictable as well as robust, and draws a parallel with medications, which produce distinct responses in a small group of people:

The answer to this question is complicated. First, even for modulators that have robust actions, there may be significant differences in their responses to threshold concentrations (Weimann *et al.* , 1997) (S). Second, many modulators show state-dependent actions (Nusbaum and Marder, 1989b; Szabo *et al.* , 2011), such that the prior activity or activity history of the network determines the extent or sign (Spitzer *et al.* , 2008) of modulatory action. Third, the action of the modulator can depend critically on other modulators (Brezina, 2010; Dickinson *et al.* , 1997) (S). That said, many networks with different underlying parameters can respond reliably to the same modulators (Grashow *et al.* , 2009), although in this study a small proportion of networks responded anomalously (Grashow *et al.* , 2009) (S). These data are reminiscent of what we see in the human population with pharmacological agents that produce anomalous responses in a small subset of people. Thus, although there are significant individual differences in circuit structures among individuals, the particular sets of network parameters found in the healthy population may be enriched for parameter sets that allow reliable neuromodulatory control under most conditions. (Marder, 2012)

The last quotation also clarifies why this procedure should still be viewed with caution, specifically because one cannot disregard individual differences when altering the structure of a neural circuit. (Marder, 2012)

In the same vein, Waisberg details the technical risks of this type of technology; he specifically addresses Neuralink. According to the author, these risks include: a) the displacement of the electrodes: there is the possibility that the ultra-thin electrodes will shift

or migrate to other areas of the brain, which could cause mechanical damage to brain tissue or even loss of signal from the chip; b) the retraction of the electrodes: it was reported that in the initial tests parts of the electrodes retracted from the brain tissue, so that the number of electrodes with the capacity to capture neural signals was reduced; (Waisberg, 2024)

Furthermore, there is the risk of c) Biocompatibility and inflammation: with inflammatory reactions, since the device is invasive, which can compromise the chip's effectiveness in the long term, in addition to the user's health; d) Mechanical instability: regarding this aspect, Waisberg mentions that hardware needs to maintain stable connections, but the point is that the brain system is dynamic and flexible. Thus, how to determine the durability of the polymer electrodes since they would be under continuous stress. In addition to these concerns, the last author reports the challenges of removal or even replacement, which is considered extremely risky, since it could additionally damage the cerebral cortex during surgery. (Waisberg, 2024)

Maia *et al* address specific cases from distinct points of view — ethical, sociological, and legal — and, given the completeness with which they address the subject, the text will serve as the basis for much of the argumentation that follows. They separate the ethical use of neurotechnologies into: non-invasive techniques in tetraplegic patients; non-invasive in a healthy population; invasive in a healthy population; and non-invasive in a patient with Alzheimer's. (Maia de Oliveira Wood *et al* ., 2024)

In the first case, the use of non-invasive NT in a tetraplegic patient: the pre-implant concern is transparency and informed consent, since contexts such as Neuralink's would require, according to the authors, the follow-up and monitoring of specialists in human rights and medical ethics regarding the results and methods, in addition to the implementation. As for the post-implant phase, the concern is that even in the case of success, there is a risk of pressuring the patients, in the case of an enhanced human capacity, such that society itself pressures the individual to adapt to the new “enhanced” self, engendering the ethical question between what is therapy and what is enhancement. (Maia de Oliveira Wood *et al* , 2024)

In the second case, the use of non-invasive NT in a healthy population to increase concentration, for example. The authors debate the functionalization of people, that is, reducing the individual to their productivity, which would intensify the pressure, whether individual or social, for high performance in a constant manner. From a corporate point of view this is also alarming, since it could instill in companies a demand for a highly focused and therefore more productive workforce. (Maia de Oliveira Wood *et al* , 2024)

In people with difficulty concentrating or learning, a demand for standardization could also occur, the authors suggest, in addition to the aspect of dependence on certain devices

and the companies responsible for enabling the use of a certain technology. This could result in a high social expectation for elevated and uniform performance, which does not corroborate inclusive practices. Another ethical point is in the educational context, especially involving children, whose idea of applying electric current to the developing brain over a prolonged period in smaller doses also lacks visibility. (Maia de Oliveira Wood *et al.* , 2024)

In addition, the profit aspect and investments in BCI research are also mentioned: the NT industry generates billions in annual profits and these are expected to double or triple in the next decade. (Kinstler, 2025). With the intensification of research and profits, the speed of the application of NTs on a commercial scale increases. The accelerated pace of development and investment increases the importance of the ethical discussion.

In the same field, with regard to the use of invasive NT in a healthy population, Maia de Oliveira *et al.* explain that the ethical concern is above all with agency and dependence, that is, technologies need a constant connection and are linked to data centers, engendering questions such as the processing of such neural data, whether there is a risk of bias in the processing structure itself, involuntarily, or whether the agency itself could have such an attribution of manipulation. In view of this, they draw a parallel with current technologies already in widespread use, such as smartphones, which already have as an implication: addiction to certain applications, negative effects from excessive use, and technological dependence on digital platforms. In addition, they ask how it would be possible to ensure that the greatest number of people could use such products to increase performance. If diffusion is not possible, economic and social inequality would also be threatened. (Maia de Oliveira Wood *et al.* , 2024)

And in the last case, non-invasive NT in Alzheimer's, the authors indicate that the specific targeting for this disease, whose neurotherapy promises to improve the autonomy of these patients, cannot create false expectations of recovery in their families, particularly those based on advertising or promises without scientific evidence; therefore, there would be, according to the authors, an ethical demand also for caution regarding the dissemination and therapeutic and clinical promises made to the public. (Maia de Oliveira Wood *et al.* , 2024)

In view of the ethical questions presented here, what have countries been doing in terms of legislation and ethical guidelines to prevent the implications conjectured here? Kinstler details some measures, such as neural privacy laws

To prevent this kind of mind-meddling, several nations and states have already passed neural privacy laws. In 2021, Chile amended its constitution to include explicit protections for “neurorights”; Spain adopted a nonbinding list of “digital rights” that protects individual identity, freedom and dignity from neurotechnologies. In 2023, European nations signed the Léon Declaration on neurotechnology, which prioritizes

a “rights oriented” approach to the sector. The legislatures of Mexico, Brazil and Argentina have debated similar measures. California, Colorado, Montana and Connecticut have each passed laws to protect neural data. (Kinstler, 2025)

The pertinence of the issue is so great that, while this work was being produced, UNESCO published a global normative framework on the ethics of neurotechnology aiming to anticipate major scientific advances without compromising human rights. The recommendation came into force on November 12, 2025, and expressed the following concern

Although its medical use is strictly regulated, neurotechnology remains largely unregulated in other areas. Many consumers use this technology without knowing it, through common devices such as *headbands* or connected headphones, which use neural data to monitor heart rate, stress, or sleep. This highly sensitive data can reveal thoughts, emotions, and reactions, and can be shared without consent. (UNESCO, 2025)

Finally, although the points of this chapter have raised more questions than answers, the discussion aimed to present the current debates and how the limits of application of these technologies are still not clear. The debate is broad, traversing themes such as social pressure for high performance, inequality of access, coercive use — even if implicitly, in order to be socially accepted — false expectations of recovery for some diseases, technological dependence, agency by large technology companies, security, storage, processing, and protection of neural data. And, above all, it reveals the possibility of acting directly on the brain with the capacity to influence emotions and shape behaviors.

In this way, themes related to the construction of the individual, as well as what it will mean to be a human — thinking, endowed with supposed free will — in the face of the possibility of behavioral interference arising from the new technologies explored here? Such reflection provokes debates about the understanding of the notions of consciousness, identity, autonomy, privacy, and responsibility, which pertain to the legal field, and for this reason will be conceptions explored below.

4 NEW DIMENSIONS IN THE CONCEPTS OF CONSCIOUSNESS, IDENTITY, AUTONOMY, PRIVACY, AND RESPONSIBILITY

The advance of neurotechnologies, which can intervene in cognition and decision-making, creates tensions in classic concepts such as consciousness, identity, autonomy, privacy, and responsibility. In this scenario, there is no intention to exhaust the subject, but only to investigate, at least minimally, the new configurations of the concepts in question,

since they are traditional concepts that would demand greater theoretical depth which this article did not propose to undertake. Thus, the purpose of this chapter is to reflect summarily on these new dimensions of the concepts in question that may have impacts in the legal sphere; for this reason, the doctrinal discussions have addressed the subject under the prism of the possibility of neurorights.

Burwell, Sample, and Racine carried out a review of the literature, analyzing beyond the questions raised in biomedical ethics but also seeking sources in medicine and philosophy, and identified

that research on BCI and its potential translation into therapeutic intervention generates significant ethical, legal, and social concerns, notably with respect to personality, stigma, autonomy, privacy, research ethics, safety, responsibility, and justice. Our review of the literature further determined that, although these issues have been enumerated extensively, few concrete recommendations have been expressed. (Burwell, Sample, and Racine, 2017)

If, on the one hand, NTs offer significant medical advances, their convergence with AI, added to non-medical, profit-driven, and commercial-scale contexts, points to reflection on what kind of human being we can create from brain manipulation or from neural data. In 1970, Delgado provoked "*The question is what sort of humans would we like, ideally, to construct?*" (Scarf, 1970)

Delgado was a pioneer in experiments on brain stimulation and on the *stimoceiver* (a radio device with the capacity to stimulate specific brain areas at a distance). He researched the suppression of aggressiveness and the amplification of happiness and intelligence. In 1963, he carried out an experiment with a bull to demonstrate that behaviors such as aggressiveness could be modified. He implanted a stimulator and radio receiver in the bull's brain and, by means of a certain stimulation, a signal was sent to the animal's brain, which stopped and calmed down. (Marzullo, 2017)

The possibility of physical control of the mind is still of interest, and for this reason Delgado's question, above, points to the relationship between programming and autonomy, that is, if it is possible to suppress or reduce anger or sadness by means of an implanted chip or by means of an electric shock in a brain area of a given individual, would that individual still be himself? In this case, Glannon explores this question of how to identify what the therapeutic limit is: what is it to cure a disease? He reflects on how to delimit what is: manipulation of personality; enhancement (normal functions potentiated?); and therapy. (Glannon *apud* Focquaert, 2009)

If the human being can be constructed, emotional states inferred, motor intentions and affective states altered, the technological risk and the concern of society and of scientists is legitimate, because, according to Kinstler, without due protection for the human mind: surveillance techniques could be employed, companies would have the ability to exploit the neural data generated from human thought; in addition, she conjectures the manipulation of decisions made from cognitive monitoring. The idea of the power to construct a human being, if taken over by corporations or by governments aiming at an idealized human — without flaws, or docile, or hyperproductive — has plagued philosophers, writers, and scientists for decades. (Kinstler, 2025).

In this field, reflection is made on the formation of opinion: how to determine that it would be autonomous, without coercion, with due freedom of thought guaranteed constitutionally? In this particular, even deliberative processes could be compromised, since it cannot be affirmed that the decision regarding a given vote would not be vitiated.

Furthermore, if a “self” can be constructed through external manipulation, the continuity of the self, the notion of personal identity, may also be threatened by the uncertain use of neurotechnologies, point out Maia de Oliveira Wood *et al.* (Maia de Oliveira Wood *et al.*., 2024)

The ANPD has already taken a position in the same sense,

Beyond the industrial potential and that of promoting the progress of science and human well-being, **technologies that interact with the brain raise ethical-legal questions of great importance**, notably due to **risks created for fundamental (human) rights such as the free development of personality, freedom of thought, privacy, bodily integrity, and non-discrimination**. According to a report of the Human Rights Council of the United Nations (UN), neurotechnologies affect human (and fundamental) rights in a unique way (UN, 2024, p. 18). For example, **neurotechnologies of the brain-computer interface type, such as Functional Magnetic Resonance Imaging (fMRI) devices and electroencephalography (EEG), instead of being used for medical diagnosis, can be employed by governments and private entities for the surveillance and monitoring of individuals** (Ienca; Jotterand; Elger, 2018, p. 270). The subject has been the object of intense academic and interdisciplinary debate¹ and has reached the most relevant international forums such as the UN (2024), the United Nations Educational, Scientific and Cultural Organization – UNESCO (2023), the Organization of American States – OAS (2023), and the Organization for Economic Co-operation and Development – OECD (2019). Thinking about the governance and legal regulation of neurotechnologies is one of the unfoldings of this global-scale debate. (Brazil, 2025, emphasis added)

One of the reflections that neurotechnologies awaken is, then, why protect mental privacy? This question can be approached in distinct ways. For now, the option is to approach

it under the ethical and legal aspect, and under such a lens the democratic aspects stemming from this discussion cannot be set aside.

Freedom of thought, although it is seen as the basis of the other freedoms, according to Maia de Oliveira Wood *et al*, the risk of brain reductionism, in which the functions neural would override integral human dignity, engenders an alert (Maia de Oliveira Wood *et al* ., 2024).

This is because, from a clinical point of view, neural data can reveal patterns and indicate psychiatric issues even before the individual has detected them, the last authors state. In simple terms, Medicine could early identify vulnerabilities which would allow them to be exploited in therapeutic contexts or for purposes of social manipulation. (Maia de Oliveira Wood *et al* ., 2024).

Mental privacy is what determines the human capacity for self-individualization, to think as a unique human being, reinforcing personal identity. According to Maia de Oliveira Wood *et al* the very evolution of the idea of the right to be left in peace demonstrates the mutation of the concept, in addition to demonstrating its currency, since it could also, according to the authors in question, protect against the decoding of thoughts and emotions. (Maia de Oliveira Wood *et al* ., 2024)

In this field of neural data, Yuste *et al* warn that the risk is the invasion of mental privacy and that, for this reason, neural data should be treated with protection similar to the other organs, to prevent the commercialization of thoughts. This is because the advance of AI may decode mental states, and thus new rights would serve to protect human identity. (Yuste *et al* ., 2017)

That is, according to the discussion proposed above, the collection and manipulation of that data, without the user's consent and without a predetermined purpose, whether by means of non-invasive devices — such as headphones, headbands, helmets, glasses, EEG, or neuroimaging — or by invasive means such as brain implants, may be subject to commodification with the aim of profit or of manipulation and surveillance for social, governmental, or commercial purposes; hence the concern of the authors cited in this chapter.

In the same sense, another question pertaining to the debate is personal identity, motivated especially by the idea that brain stimulation technologies, invasive or not, have the capacity to alter the behavioral pattern, mental states, and therefore also have the ability to mischaracterize a given individual personality. And at this point, what is at stake, above all, is the preservation of a given identity and of the integrity of an individual.

Jotterand and Giordano set out cases in which neurological interventions produced behavioral and identity changes and thus proposed a responsible clinical use for brain stimulation techniques. They cite, for example, Phineas Gage, whose accident with an iron bar destroyed part of his left frontal lobe, and who, before, was a calm, intelligent, disciplined man and, after the accident, became impatient, rude, and sarcastic. According to the text, the change was so radical that Gage's friends said he was "no longer Gage". (Jotterand and Giordano, 2011)

The same authors also cite the case of Mr. Garrison with moderately advanced Parkinson's, who: before the deep brain stimulation, carried out for the treatment of the disease, had a quiet, pragmatic, shy personality and had also been diagnosed with disease-related apathy. After the procedure, the motor improvement was significant; however, he became extroverted and sociable, had a change in political orientation (previously Republican, then Democrat), as well as coming to defend and make donations to environmental causes. In this sense, the authors point out, the patient's behavioral and monetary pattern was drastically altered. (Jotterand and Giordano, 2011).

The authors also point out other results in which patients came to have a certain *joie de vivre* after the treatment. But this concerns them, specifically, in the case of this type of stimulation if carried out outside medical use with the specific objective of changing the personality or altering the subjective experience of the self. Jotterand and Giordano believe that this trajectory would be neither impossible nor improbable, considering the economic and social forces that influence neurotechnological interventions. (Jotterand and Giordano, 2011)

The examples above served to conjecture what personal identity will mean if it can engender a change in personality, for example. Levy discusses whether brain intervention by means of chips or drugs for emotional alterations creates a new self and threatens personal authenticity, or merely removes obstacles to a potentiation of the self (the extended mind thesis), and that for this reason the question, for him, **would be which interventions to permit and under which conditions** thus moving away from the discussion of whether or not we should permit mental interventions (Levy, 2007, emphasis added)

The last paragraphs reveal the idea that if the mental space can be inferred, monitored, and even manipulated by techniques such as the already explained neuromodulation, without consent, autonomy and free will may also be compromised. Under this aspect, Garrafa highlights how autonomy and individual responsibility must be respected in decision-making

Article 5 – Autonomy and Individual Responsibility. The autonomy of individuals to make decisions, while taking responsibility for those decisions and respecting the autonomy of others, is to be respected. Special measures are to be taken to protect

the rights and interests of individuals not capable of exercising autonomy. (Garrafa, 2005)

Still exploring the example of Mr. Garrison, whose political orientation went from Republican to Democrat, the debate touches on another point of these neurotechnologies: the influence on decision-making power. (Jotterand and Giordano, 2011). In this case, the free and autonomous thought of the individual can also be affected, because if a brain stimulation or a device in interaction with the brain (BCIs) can manipulate a certain desired decision, how to determine that the action or choice was taken by the individual, since there was influence from the device or from the stimulation? From this question also derives the attribution of legal and moral responsibility for acts committed under such interference.

In the sphere of accountability, under the legal prism, Andorno and Ienca argue that these neurotechnologies can leave the individual unprotected and suggest that traditional human rights (privacy or freedom of thought) would not be sufficient to protect against the risks arising from neurotechnologies. They indicate that risks such as the recording of brain activity, the decoding of mental patterns, behavioral modulation, and interference with decisional autonomy require a specific legal category with the creation of neurorights: the right to mental privacy, to mental integrity, to cognitive liberty, and to personal continuity. (Ienca and Andorno, 2017)

The unfoldings of neurotechnologies continue; derived questions such as criminal liability and the right against self-incrimination also point to the importance of the discussion proposed here. Munhoz, De Ávila, and Pereira have already discussed the (il)legality and (il)licitness of the evidence, as well as of the highly personal rights of the investigated party in the production of evidence using neurotechnologies to access neural data. They attempted to explore whether evidence based on NT affects the right to silence and whether access to mental information violates the constitutional rights of the accused. (Munhoz, De Ávila, and Pereira, 2024)

For example, in the case of the brain reading of an accused person in which a neuroimaging technology is used and he is exposed to the crime scene and the brain recognizes the scene even though the accused has not revealed such information. In this particular, the risk of the mental reading of an accused person adds debates to the scenario of neurotechnologies and their implications.

Finally, Hamburg sets out the central concern with neurotechnologies and why it differs from the others, above all because it can directly access the biological mental substrate, and adds *“Any new technique for understanding how the brain mediates behavior could affect our*

lives for better or worse." (Hamburg apud Scarf, 1970). And it was this disquiet that the present research attempted to demonstrate.

5 FINAL CONSIDERATIONS

The advances of Neuroscience and of AI, added to the growth of Neurotechnologies, inaugurate a panorama of reflections about the human mind. Considering the access to brain activity and the modulation of mental processes by means of invasive or non-invasive techniques, some ethical implications may stem from access to such mental processes.

The potential of neurotechnologies is promising and desirable, above all in the treatment and diagnosis of psychiatric and neurological diseases such as Alzheimer's, Parkinson's, and depression. The sophistication of these instruments can promote health and well-being for individuals who are not healthy. However, the experiments and techniques, many still under testing or not accessible to all publics, engender questions about the unintentional or intentional consequences that may arise from the development and expansion of the use of these neurotechnologies.

Based on the records of brain activity, studies presented suggested that mental patterns could be decoded, and behavioral modulation, in addition to psychic surveillance with commercial or governmental and social objectives, concerns scientists, because interference in behavior, as in the cases analyzed by Jotterand and Giordano, brings reflections about individual autonomy, free will, human identity, consciousness, in addition to bumping up against the protection of mental privacy and the legal accountability that may eventually arise from a modulated action. It is still early to say whether a modulated action will be considered vitiated or not.

In light of the above, the general objective of understanding the ethical implications of new technologies in Neuroscience was explored in contexts with healthy and non-healthy individuals and with invasive and non-invasive methods. As a result, authors such as Maia de Oliveira Wood and *et al* identified that there is a social risk of pressuring an individual to adapt to a new "enhanced self", engendering the ethical question between what is therapy and what is enhancement.

Another risk is that the corporate, educational, or governmental demand for a certain behavior, desirable to such spheres, may be forced collectively through the use of the techniques explored in the text. For example, imagine a company that wants a highly focused and productive workforce and aims to modulate such behavior, or a government that desires a certain sexual orientation, for example.

Another ethical point indicated was the profit aspect with respect to the agency and dependence of some neurotechnologies which require constant connection and are linked to data centers. At this point, reflections regarding the processing of the recorded neural data, the risk of bias or not in the processing structure itself, involuntarily or not, are also revealed.

Furthermore, the egalitarian aspect of access to such technologies was questioned. In a case where such an equitable perspective is not possible, the theme of social, economic, and technological inequality would also be linked here. Aspects such as an ethical demand in the disclosure and promises made to the public about treatment and diagnosis using these technologies were also mentioned.

Furthermore, technical risks such as the possibility of displacement and retraction of the electrodes, biocompatibility, inflammation, and connection instability also press for the tests and studies in this area to be transparent and with informed consent, since specific cases such as those of Neuralink generated social noise especially regarding the supposed lack of these two components.

In this way, Maia de Oliveira Wood *et al* maintained the follow-up and monitoring by specialists in human rights and medical ethics in the implementation and in the results of these studies. In summary, ethical implications such as social pressure, inequality, coercive use, false expectations of recovery for some diseases, technological dependence, agency by large technology companies, security, storage, processing, and protection of neural data were presented, fulfilling the general objective of this work.

In addition, the combination of neural data mapping, identification of thought patterns, direct action on the brain, and the possibility of encouraging or discouraging a certain behavior revealed the theory of the possibility of individual and collective behavioral interference. Thus, should the assumption that emotions may eventually be intensified or reduced come to pass, self-perception would also be affected, giving rise to an estrangement from oneself and disturbing the idea of personal identity.

In view of this possibility of affecting individual characteristics, with the ability for depersonalization, the work explored new contours with respect to classic themes such as the construction of the individual, consciousness, identity, autonomy, privacy, and responsibility, answering the initial question: whether the new technologies in Neuroscience can bring ethical impacts to such concepts.

Finally, as a result, it was concluded that, yes, there can be ethical impacts on the classic concepts highlighted. The authors presented indicated that there may be impacts on mental privacy if neural data is accessed without consent and without the due clarification of the reason for collecting it.

Furthermore, studies presented, such as those of Burwell, Sample, and Racine, indicated that should thoughts and decisions receive interference, there is the possibility that such manipulation violates autonomy, since the individual will not be certain whether he is the author of a given decision or behavior. In addition, some techniques presented in the text, the case of Garrison, for example, in which a behavioral change was produced, reveal debates about personal identity and moral and legal responsibility.

In light of the above, many questions presented here lack discussion; however, from the ethical and legal point of view, one of the most notable concerns an action altered by a neurotechnology: if it is considered a violated and induced decision, this matters, because it may indicate a difficulty in determining whether the action that received the interference is autonomous, that is, the individual's own or not. For now, this work did not intend to exhaust the subject, but only to contribute to the first notions about the ethical implications of the new technologies pertaining to the brain sphere.

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CARTESIAN GEOMETRIZATIONS: AN INTERDISCIPLINARY CONVERSATION AMONG PHYSICS, PHILOSOPHY, MEDICINE AND CLINICAL PHILOSOPHY CONCERNING FINITUDE

GEOMETRIZAÇÕES CARTESIANAS: UMA CONVERSA INTERDISCIPLINAR ENTRE FÍSICA, FILOSOFIA, MEDICINA E FILOSOFIA CLÍNICA ACERCA DA FINITUDE

GEOMETRIZACIONES CARTESIANAS: UNA CONVERSACIÓN INTERDISCIPLINARIA ENTRE LA FÍSICA, LA FILOSOFÍA, LA MEDICINA Y LA FILOSOFÍA CLÍNICA EN TORNO A LA FINITUD



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ABSTRACT

Tragic thinkers (Nietzsche) sought an understanding of Arché using a form considered today as inter and transdisciplinary. In this article we have developed three itineraries to address the issue of time and its implication in therapeutic care. In the first itinerary we return to Apollonian and Dionysian forces; in the second itinerary we bring the geometrization of thought (Bachelard) and complex thinking (Morin) to re-discuss the psi theory models of mind (third itinerary) and the proposal of new mental architectures that gain meaning from non-euclidean geometries. So, the purpose of this article is to re-establish a dialogue between Philosophy, Physics, Mathematics and Medicine, having geometry as a background to think about time and finitude.

Keyword: Time. Physical. Finitude. Geometry. Clinical Philosophy.

RESUMO

Os pensadores trágicos (Nietzsche) buscavam uma compreensão da *Arché* valendo-se de uma forma considerada hoje de inter e transdisciplinar. Neste artigo desenvolvemos três itinerários para abordarmos a questão do tempo e a sua implicação no cuidado terapêutico. No primeiro itinerário retomamos as forças apolíneas e dionisíacas; no segundo itinerário trazemos a geometrização do pensamento (Bachelard) e o pensamento complexo (Morin) para rediscutimos os modelos de mente da teoria psi (terceiro itinerário) e a proposta de novas arquiteturas mentais que ganham sentido a partir das geometrias não euclidianas. De modo que o objetivo deste artigo é reestabelecer um diálogo entre a Filosofia, a Física, a Matemática e a Medicina tendo a geometria como pano de fundo para pensarmos o tempo e a finitude.

Palavras-chave: Tempo. Física. Finitude. Geometria. Filosofia Clínica.

RESUMEN

Los pensadores trágicos (Nietzsche) buscaron una comprensión del Arché empleando una forma considerada hoy como inter y transdisciplinaria. En este artículo hemos desarrollado tres itinerarios para abordar la cuestión del tiempo y su implicación en el cuidado terapéutico. En el primer itinerario retomamos las fuerzas apolíneas y dionisíacas; en el segundo itinerario traemos la geometrización del pensamiento (Bachelard) y el pensamiento complejo (Morin) para volver a discutir los modelos psi de la mente (tercer itinerario) y la propuesta de nuevas

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arquitecturas mentales que cobran sentido a partir de las geometrías no euclidianas. Así, el propósito de este artículo es restablecer un diálogo entre la Filosofía, la Física, las Matemáticas y la Medicina, teniendo la geometría como trasfondo para pensar el tiempo y la finitud.

Palabras clave: Tiempo. Física. Finitud. Geometría. Filosofía Clínica.

1 INTRODUCTION

Time is the term upon which we reflect and within which we existentially find ourselves immersed. This concept, addressed in the most diverse areas of knowledge, gives rise to reflections that are at times abstract, at times concrete, to the point of making speech, the act of saying, impossible (Santo Agostinho). In this article we pursue this precious concept in its many appearances throughout the act of knowing, focusing on its geometric appeals (Mathematics), on its subjective dimensions (Psi areas), and on its field of infinity and finitude (Philosophy, Physics and Medicine). The aim of this article is to re-establish a dialogue between Philosophy, Physics, Mathematics and Medicine, with geometry as a background capable of establishing a tacit relationship with these areas of knowledge, especially Clinical Philosophy (CP).

Today, more than two thousand five hundred years removed from the Greeks, the correlation between these areas of knowledge (Philosophy, Physics, Mathematics and Medicine) seems absurd and unscientific; however, we shall point out the present relevance of these relationships through three itineraries. In the first, we shall return to what Nietzsche called tragic knowledge, namely, a knowledge in which Apollonian and Dionysian forces were opposed yet complementary, resulting in a worldview in which the void, the nothing, the infinite—themes set apart from our knowledge (Heidegger)—permeated existence. In the second itinerary we shall engage in dialogue with the concept of interdisciplinarity that permeates complex thinking (Morin) in the light of Gaston Bachelard. In the third itinerary we enter the field of subjectivity and the need to update our mental spaces with the most current theories of Physics. In both itineraries, Clinical Philosophy (CP) is focused upon as a locus of investigation of these developments. A locus that refers us directly and indirectly to the fragility, to the finitude that permeates us as human beings.

CP is a Brazilian therapeutic proposal, systematised by the gaucho Lúcio Packter, which draws upon philosophical thought for psychotherapy. A decolonial appropriation of thoughts regarded as abstract for the assistance of people situated in the world, that is to say, the application of Philosophy. An application that has a long tradition in the Western school and which is being taken up again nowadays (José Barrientos, Jorge Dias, Lou Marinoff, Tin Lebron, Yves Leloup, to mention a few), who discuss among many things one premise: if philosophical thought is the support and foundation of various therapeutic processes, why can it not be applied to philosophical practice itself as a practice of care? Such a question plunges us into ethical and methodological discussions that we shall not enter into; however, we shall follow the path that the great physicists, mathematicians and jurists have always taken, that is, to transpose philosophical thought, giving it materiality, existentiality. In other

terms, in the undergraduate study of Philosophy, ideas are taught as abstract entities, devoid of existentiality. They are empty and infinite concepts that inhabit the world of ideas in a clear distinction between being and thing, body and mind. Nevertheless, in Physics, in Mathematics, in the Social Sciences, in Biology, in Medicine, the ideas of philosophers take on body, materiality, formulae, the building of worlds, technological elaborations. It is from this place of praxis that Packter discusses philosophy as a bearer of meaning for thinking, dialoguing with and caring for human pains. Not in their medical sense, but in their onto-existential dimension.

In ontology, the dimension of time arises, erupts, appears. And alongside it the confabulations about the finite and the infinite. The most imminent of these perceptions in the field of Physis is the apeiron of Anaximandro de Mileto. The eminent professor Roberto de Andrade, reflecting on the elucidation of what this concept might be, suggests:

The word can be translated as “infinite”, “indefinite”, or “unlimited”. It is an abstract term, perhaps invented by Anaximandro himself. It is possible that he wished to indicate with this word a kind of matter that does not correspond to anything definite, but that can take on the appearance of all the kinds of substance that we know. Perhaps this idea was a step forward, a new degree of abstraction, from the idea of Tales. (...) Anaximandro seems to have imagined an unknown substance, perhaps even impossible to observe, which could serve as the origin of all the others. From the apeiron, which is neither hot nor cold, heat and cold would arise; from the apeiron, which is neither hard nor soft, hard and soft substances would arise. (Andrade, 1994, p. 36-37)

This search, not for the Arche, but for the understanding of time, has run through the history of philosophical, mathematical and physical thought. The attempt to name this indefinite, this amorphous state that gives form to things, this infinite, has been the subject of long and elegant discussions. In one of these discussions, the amorphous, the formless, this indefinite, acquires the concept of anguish in Heidegger, of nothingness in Sartre. Both assist in the philosophical experiment of rooting philosophy in the concreteness of the world.

In philosophical training, students are led to believe that concepts such as apeiron are no more than abstract ideas, lost at the beginning of philosophical practice. Mathematics students are led to discuss the infinite, but sometimes without dialoguing with the philosophical thought that underpins it. Inter- and transdisciplinarity help to bring knowledge closer to a totality.

One may, in a brief and swift historicity, point out how this concept of the infinite unfolds in Isaac Newton in the “invention/discovery” of the calculus. In Georg Cantor, a magnificent German mathematician of the twentieth century, with the demonstration of his studies on the existence of many infinities. In quantum mechanics and the need for renormalisation.

The search to name the infinite runs through the attempt to answer real problems, to solve concrete questions of the human spirit. It is in this sense that time, finitude, death—more than empty abstractions—are questions dear to existence and to existing. So that the themes, the concepts, bring professionals closer together, break down specialisations, and create spaces of constructions and investigations that are at times new, at times tragic, in the historical sense of the first itinerary.

2 FIRST ITINERARY: TRAGIC KNOWLEDGE. CIRCULAR TIME

When Nietzsche returns to the Greeks, from a more aesthetic than epistemological perspective, more musical than literary, he hears, more than he sees, that the “Greek miracle” contained the balanced, complementary form with which they dealt with two opposing yet complementary forces: the Apollonian and the Dionysian. The Apollonian, directly related to the god Apolo, is related to beauty, to form, to elegance, to the visual, to the clear, to the day. And the Dionysian, related to the god Dionísio, is associated with shattering, intoxication, the playful, wine, ecstasy, the dream. Both bring and have music as a positive intersection. Nietzsche saw in this combination what he called the tragic, understood by us in another work as follows:

The TRAGIC is the force, the power that escapes form and beauty, and it is equally the ordering, the measure, the measurability of the power that escapes. It is the representation of the world and the world itself. It is syntax and semantics, concept and music, opposites and complementarity. The TRAGIC is what contains and overflows existence at one and the same time. The TRAGIC is existence and transcendence, the physical and the metaphysical. The representation that oppositions and antagonisms are the fruit of human language, of human understanding (Heisenberg and the Uncertainty Principle) and not of being itself, of the world itself (Bohr and the Complementarity Principle). The TRAGIC turns out to be the impossibility of expressing oneself other than through antagonisms that complement one another, and which is symbolically represented by Nietzsche as Apolo and Dionísio. The Apollonian and the Dionysian are theoretical constructions that allow for the possibility of unifying, in the best style of the Romantics, epistemology and aesthetics. (SANTOS, 2021, p. 64)

In other terms, the Greek tragic overflows and unveils the beauty of truth, the symmetry of beauty, the elegance of justice. Three angular bases for the knowledge we shall foster in this article. So that the tragic is, then, the complementarity of threatening, terrible forces which, however, the Greek genius embellished and balanced. This balance is pointed out in music, in science, in philosophy, in medicine, in art, in the search for meaning. In truth, part of this meaning is well expressed in the epistemological tradition of the West through shadows.

The Greeks were those who dealt with shadows, whether with Tales de Mileto (624 BC to 546 BC) measuring the size of the pyramid by them, or with Erastóstenes de Cirene (274 BC to 194 BC) measuring the circumference of the Earth; or with Platão and his consecrated allegory. In each of them there emerges the capacity of a culture to see and to seek the understanding of what is seen from a different, non-apparent perspective. To access one part of existence without concealing, denying, or annihilating the other. This “tragic knowledge”, Nietzsche affirms, Socratism unbalanced by becoming more Apollonian than Dionysian, that is, more precise, conceptual, formal, solar, mathematical.

In an implicit dialogue with the Pythagoreans, later generations delineated a world of precision, of quantification, of normalisation (Apollonian), as being capable of explaining and replicating the Greek universe (Santos, 2021). Forgetting the highly qualitative, Dionysian aspect of the Pythagorean current, which in its origin is confused with sects of religious initiation.

In Nietzsche's view, the Socratic reading caused an imbalance that silences the tragic. A silencing that causes philosophy, science and medicine to abandon and neglect finitude, death, non-being. Components inherent to existence which can be symbolised in King Midas's pursuit of Sileno, who thus prophesies to the king:

Miserable and ephemeral race, children of chance and torment! Why do you compel me to tell you what it would be most beneficial for you not to hear? The best of all is utterly unattainable for you: not to be born, not to be, to be nothing. After that, however, the best for you is to die soon. (NIETZSCHE, 2003, p. 36)

Far from a pessimistic view, from a nihilism, Nietzsche saw in this pursuit, in this tragic, the necessity of an affirmation of life. A necessity that places him as one of the pioneers of existentialism, since it is in existence that the tragic is realised. Since the tragic is a component inseparable from existing. And in this existing the forces of life cast us forth, whipping us along, leading us to attribute meaning.

Here multiple paths open, of which we shall point out two. First, the concept of will to power (WP) and eternal return (ER).

The second and prior is what Aristóteles called Thaumá. A Greek word that means ASTONISHMENT. Not in the sense of fear, of terror. Astonishment in the sense of admiration, contemplation, indignation.

This astonishment is the original startle that the child would feel upon being born, upon perceiving that it had truly been born, as Alberto Caeiro tells us in O Guardador de Rebanhos. This astonishment/Thaumá is the origin of Philosophy. However, more than the origin of Philosophy, it is the origin of all questioning, of all inquiry, of all art, of all science, of all

knowledge. They are born of this original amazement. An amazement that, when uncorked, glimpses the central problem that accompanies us—finitude. We die.

Death is the central theme of existence, and alongside it its opposite and complementary part, life. It is in the search for the understanding of this mystery that we bring together life and death, or more precisely, philosophy, physics, mathematics, medicine, clinical philosophy. But, before entering into this itinerary, we shall stroll through the Nietzschean concept of WP and ER, a swift stroll.

Nietzsche, as a good tragic philosopher, also thought on the basis of problems. Many researchers and commentators of Nietzsche establish a dialogue of his theories with Biology; however, I have preferred to bring his dialogues with Physics.

The criticisms that Nietzsche makes of Kant internalise a Newtonian conception of the world. Kant is the first to awaken philosophers from the dogmatic dreams of an ontological explanation of the universe and of existence. From a central problem, namely, how was it that Physics, which had been subaltern to Philosophy until a few centuries ago, managed in so little time to advance so much? Kant shows us that, by abandoning the WHY and moving towards the HOW, Physics evolved more than Philosophy and Theology. But can a philosopher abandon the why?

Kant shows us that he cannot, while at the same time he gives us the itinerary as to what to ask and as to what we may expect answers to. Thus, he establishes the limits of reason. Philosophical and theological thought has no limits. More precisely, the theological has the epistemological limit of faith. The philosophical, on the other hand, can produce interminable arguments that existentially lead nowhere. And Kant, like others, had already believed that knowledge is Apollonian, that is, metric, reproductive, Cartesian, scientific. To know is methodically, in a Cartesian manner, to pave paths of rational, intelligible understanding, with clear and distinct ideas.

These certainties trouble Nietzsche; he wishes to understand not what is being seen and shown, but what is being heard yet hidden. The concepts of WP and ER mark this place, this relationship with the infinite, but tied to existence, to life. In the ER, the German philosopher of the nineteenth century rewrites Kantian ethics no longer through the thou shalt of the power of inertia, but through the thou chooseth, through the act of one's will.

In the Kantian thou shalt, in the Newtonian cosmos, there is a God who normalises all forces and all wills. There is a normal force that balances actions in spite of the subjects. In Nietzsche it is the will to power, it is the amor fati that derives in subjects the 'responsibility', the joyful taste and enjoyment of choosing only that which the subject would not mind repeating throughout all eternity.

This circular cosmos in which all things tend to repeat themselves. This cosmology in which there is no God to punish or to save is the tragic idea in its Greek conception before Sócrates. It is this dialogue with life, with existing, that caused those thinkers to have at one and the same time done philosophy, mathematics, geography, physics, medicine, astronomy. There was no distinction, because all knowledge was life.

Knowledge dialogued with the real problems of these men and with desperate, hopeless, joyful, wrathful attempts at explanation in the search for a meaning that transcended Apollonian reason and entered into the intuitive Dionysian. This encounter being the tragic. In other terms, tragic thinkers sought an explanation that had to be rational and not to resort to the gods, but at the same time, they understood that reason, in its Apollonian attributes, has limits. The marker they used was one: how to explain the phenomenon without divinising them?

Yet there is an immense distinction, an abyss, between the divinisation of the phenomenon and the attempt to mask the mystery that surrounds life and death. The great scientists, philosophers and physicians looked at this abyss without averting their gaze. They went to seek meaning. Some groups of historians and commentators, however, created a line in which the Dionysian was removed from existence. It was elevated to the condition of the unnatural, the abnormal. It is thus that Sócrates, who fell into permanent trances, remaining for hours in a catatonic state, conversing with his Daimon, was elevated to the condition of the first rational philosopher, with these events almost erased from his history.

It is in this same historiographical perspective that Newton is elevated to the condition of the icon of modern science, that is, the science of calculus, of mathematisation, of precision, at times even of atheism; when the most appropriate thing would be to see him as the “Last of the Magi” (THUILLIER, 1994; WESTFALL, 1995; KOYRÉ, 2001).

In the same historiographical lineage we have Kant who, if on the one hand he modelled the thought of Newton, on the other dialogued with the thought of the mystic Emanuel Swedenborg, a Swedish scientist, physicist, philosopher and spiritualist of the eighteenth century (DAVID-MÉNARD, 1996).

All the limits of reason that Kant establishes between knowledge and the probable have these two antipodes as their parameter. So that, outside a historiography that makes Apollonian cuts, that is, believing that History has an internal rationality, a linear horizon whose making must be stitched together by the historian on the basis of great deeds, great names, great geniuses, without opponents and interlocutors, we wish to present another. Another that erupts when we open up to more thematic, more fluid conceptions, in which the themes, the beings, the characters converse among themselves regardless of time, area,

locality. This “indefinite, amorphous” history is a complementary part of definition, of conceptualisation.

3 SECOND ITINERARY: GEOMETRY AND/OR COMPLEX THINKING, LINEAR TIME

To think about History and the very making of history refers us to a tacit concept that permeates this article—time. We shall not dare to conceptualise it, but we shall highlight it as being the space, the place, in which various areas of knowledge come together developing new existential cartographies. These cartographies allow us to use the complex thinking of Morin to see the whole in a part and, from this whole, to understand the parts.

In this mirroring we wish to reveal the concept of interdisciplinarity. Isabel Brasil Pereira reminds us that: “for Piaget (1981, p. 52), interdisciplinarity can be understood as the ‘mutual interchange and reciprocal integration between various sciences’.” It is this integration that the complex thinking of Morin elicits.

Morin, like Bachelard, models the thought of Descartes, presenting new readings. Morin elaborates this discussion on the basis of the idea of the recomposition of the Cartesian parts. Thus Descartes reminds us in the Discourse on Method:

The first was never to accept anything as true that I did not evidently know to be such; that is, carefully to avoid precipitation and prejudice, and to include nothing more in my judgements than what presented itself to my mind so clearly and so distinctly that I had no occasion to call it into doubt. The second, to divide each of the difficulties that I examined into as many parts as possible and as were necessary in order to resolve them better. The third, to conduct my thoughts in order, beginning with the simplest and most easily known objects, in order to ascend, little by little, as by degrees, to the knowledge of the most composite, and even supposing an order among those that do not naturally precede one another. And the last, to make in every case enumerations so complete and reviews so general that I could be sure of omitting nothing. (Discourse on Method, p. 21)

Morin proposes the recomposition of these parts in search of a totality that positivism, equally French, abandoned. Another aspect to highlight is that Morin seeks not the idealist, German totality that Comte, a good Frenchman, opposed. The totality that Morin seeks is the one that approaches what we are calling tragic.

The totality he yearns for is that philosophical dream of seeing the whole, that is, of dialoguing with all the parts, of dialoguing with the multiplicity of gazes. Upon entering these parts and dialogues, to understand, although not necessarily visualising, that the organisations and compositions of this multiplicity may occur in various modes, in many forms, in many ways (listening is one of them). Whether through a linearity seeking the cosmos and causing entropy; whether through a chaotic circularity generating new types of

order (Ilya Prigogine); whether through multiple, varied orderings whose hallmark, whose essence, is holography (Bohm) of each part reflecting the whole and this whole multifaceting innumerable parts. Order and chaos interpenetrate one another, consolidating life, existence, the tragic.

Morin closes for us this perspective that re-elaborates the place of the specialist. He (the specialist), possessing one part of knowledge, must dialogue with other areas of knowledge in order to visualise, listen to, scrutinise a possibility of totality, originating now not from a single point, or from a single man/woman, but from interdisciplinarity, from a network of interaction.

This vision of totality, constructed by means of almost alchemical amalgams, is called, in clinical philosophy, autogeny. Lúcio Packter thus states in the Caderno G3: “An autogenous process can be illustrated when we partially fuse two metals and thus weld them together.” (Packter, p. 7).

These chemical combinations that result in substances other than the two or other initial ones are how the systematiser of CP understands the interaction of aspects of the structure of thought, amalgamating the elaboration, the expression of a singularity. Let us see how the clinical philosopher Cláudio Fernandes presents the concept:

The word autogeny (...) draws attention to the fact that it is not a common word, neither in philosophy, nor in the clinic, nor in the sciences. Composed of the Greek word “auto”—that which is one's own, that which does not depend on third parties—and also of the Greek “genos”—origin or birth. Directly, without complicating, “autogeny” can be understood as the quality of that which is originated by itself, independently of force or resource external to itself. (FERNANDES, 2021, p. 257)

Autogeny, as understood by us in Clinical Philosophy, is at one and the same time the overall vision, the vision of totality, that is revealed at the end of the stage, just as it is the vision of totality that presents itself in each part of the stage. Stages that are didactically taught, divided in a Cartesian manner into three great axes that are structured from the gathering of historicity into: a) categorial base; b) structure of thought (ST); c) submodes (SM).

Every elaboration begins in the narrative of one's own life, told by the person themselves, HISTORICITY. And, possessing this data, the clinical philosopher situates this other existentially, (a) categorial bases. Observes what inhabits them (b) structure of thought. Understands their modes of being (c) submodes. (AIUB 2010, GOYA 2014, CARUZO 2020, CLAUS 2013, PACKTER 1997, CARVALHO, 2008). Nevertheless, each of these stages, of these phases, taken in isolation, cannot remove the epiphany of the face (Levinas). At each

stage the analyst cannot fail to re-cognise the PERSON in their entirety before them. This recognition takes place through autogeny.

In other words, it is the alchemical resource that is in all stages and that will once again unveil itself in the whole. It is beginning and end. Inside and outside. Self and other. Approximation and distancing at the same time. In all the parts it is the person who is sought. And in this totality of the search it is the singularity of the person that unveils itself and makes itself known. That which mirrors this being in itself and not another. Opening up to the same and another paradox, since that which in him is wholly otherness, and, consequently, the identity of the face, that is, human universality. Yet a singular human being, for that face is his. The miscellany of times, places, circumstances, relationships fuse together, amalgamate, forming and constituting the person. These paradoxes of the universal in the face of the singular touch upon the questions of our geometric thinking.

The “New Scientific Spirit” of Gaston Bachelard, more than modelling the “Discourse on Method” of Descartes, opens up a guide to understanding that is very dear, though little explored, the geometrisation of Western thought:

(...) let us first recall the long unity of geometric thought: from Euclides and for two thousand years, geometry receives, without doubt, numerous additions, but the fundamental thought remains the same, and one may believe that this fundamental geometric thought is the foundation of human reason. (Bachelard, 1968, p. 26)

Much is spoken of the influence of the thought of Aristóteles on Western culture, but at times we forget to mention the force of the thought of Euclides. His geometric, Platonic vision, in many measures of the world, was only overturned, or perhaps questioned, in the eighteenth/nineteenth century with Johann Carl Friedrich Gauss (1777-1855), Georg Friedrich Bernhard Riemann (1826-1886) and Nikolai Ivanovich Lobachevsky (1792-1856). Hence, the consolidation of such a conception takes place truly in the twentieth century with the theory of relativity.

For nearly two thousand years our mental architecture was structured in a linear, Cartesian manner. Thoughts outside this notation were regarded as discordant, abnormal, mad. The parametrisation instituted by the Newtonian mechanistic paradigm entered into social relations and even into our understanding of psychic structuring.

The success of industrial mechanics occupied all the spaces of the human mind and imperceptibly led man to apply it to another reality: to society. This, before the advent of science, was conceived as a body of hierarchised forces that moved within a static system, the ancien régime. (...) As science produced industrial mechanics to transmute the order of nature, it will now produce social mechanics for the <magus> who

produces technical artefacts; here the scientist appears as the <revolutionary> who produces new social regimes. The social revolution came after the industrial revolution. The latter is considered the matrix of the former. (BUZZI, 1985, p. 113)

This matrix establishes a new cosmos, or a new paradigmatic organisation of understanding, which spreads out to the various segments from the social to the psychic. Segments of a straight line that we are at all times seeking to interrelate, mirroring an interdisciplinary understanding in what Morin bequeathed to us as complex thinking.

It is in this segment that we can observe the various currents and historical interpretations, bringing together the most diverse historiographies. Historiographies which, when they ask themselves about the making of history, open up a distinction between it and the Philosophy of History, although they interpenetrate one another (MALERBA 2016; RUSEN 1987; TOPOLSKI 1999; COSTA LIMA 2011; BURKE 2011; to mention a few who elucidate these approximations and distinctions). More clearly, when we enter into the concept of time, various fields of knowing and of knowledge have their contributions to offer.

History cannot be left out, but our search is not historiographical, rather it is the interdisciplinary approximation that opens us up to the complexities that Morin explores so well and which can be found in Bachelard decades earlier:

Einsteinian mechanics increases the comprehension of Newtonian concepts. Brogliean mechanics increases the comprehension of purely mechanical and purely optical concepts. Between these last two groups of concepts, the new physics determines a synthesis that develops and completes Cartesian epistemology. If we knew how to double objective culture with a psychological culture, absorbing ourselves entirely in scientific research with all the forces of life, we would feel the sudden animation that the creative syntheses of mathematical Physics give to the soul. (Bachelard, op. cit., p. 151)

We insist on Bachelard because, besides the dialogue with the current of complexity of the French school of which he is part, he was one of the first to point out the need for Philosophy, for the human sciences, to accompany the developments of mathematical Physics.

It is still by meditating upon the object that the subject has the greatest chance of deepening. Instead of following the metaphysician who enters his room, one may, therefore, be tempted to follow a mathematician who enters the laboratory. Soon, indeed, there will be inscribed over the door of the laboratory of physics and chemistry the Platonic warning: 'let no one enter here who is not a geometer.' (Idem, p. 143)

It is curious that the warning proposed by the French physicist, far from calling for an objectivist realism, opens the doors to reveries, dreams, the psychoanalysis of fire. It opens

the doors to a highly tragic science, by allowing the Dionysian elements of scientific practice to enter the laboratory. Bachelard's criticism is of the post-Kantian.

His criticism is of the closed bodies of knowledge that do not open up to new experiences and continue to idealise a world that has been altered, complemented. In the incomprehension or myopia of this new scientific spirit, pseudo-problems are fantasised and created that only exist in the philosophical obstinacy of not experiencing the advances brought by Physics.

The radicalness of this criticism, in his eyes, lies in the philosophical insistence on seeing a world through the Cartesian-Kantian lens, whether through the body-mind duality, or through the understanding of space and time as a priori and absolute categories. But, before entering into this psychologism, we shall briefly bring a historiographical vision through the geometric lens, and how, in this lens, we shall visualise the fields of the human psyche (Morin's complexity).

Apparently, the first historical imaginary concerning time seems to be circular. It is thus that the mythoi are told, narrated, in the most diverse traditions, and remain current even today (Levi Strauss, Joseph Campbell). An event, which erupts through magical designs, takes on corporeality and is repeated each time it is re-told.

This circularity is the notation of the tragic. It is what Nietzsche heard and only Wagner understood. It is the return of the same, but it is above all the hero's attempt to defeat the Moirai, to overcome their destiny. The heroes, both in the Greek mythoi and in the most diverse cultures, are precisely those who, knowing their destiny (the circularity of the prophecy), struggle against it and, in precisely this, end up reaffirming it.

In a subsequent step, in the search for a rational explanation of facts and events, thought acquires a linearity. An amazement/Thauma at trying to explain natural phenomena not through the gods. The image would be a segment of a straight line that detaches from the circle. This idea and will, which no longer wishes a return of 360° to a narrative explanation of the world, is more than the beginning of philosophising. It is the hallmark of thinking.

A thinking that even re-turns upon itself, in a process of reflection that dialogues with the shadows we pointed out in the first itinerary. A thinking that progressively liberates itself, creating thousands of segments of straight lines, often parallel, sometimes perpendicular to one another. In any case, they are linear. A linearity which, through a process of amnesia, forgets the circle and comes to postulate that a segment of a straight line was the beginning of everything and that there is an end to everything (Truth and Lie in the Extra-moral Sense).

A linearity that, centuries later, will acquire factuality and causality. From this belief in beginning and end, one comes to draw a cause-consequence relationship that crystallises a

linear understanding of historical facts and events. Event (A) was caused by factor (X), almost in a vectorial, planified relationship, similar to two magnetic, gravitational forces in action.

In this new construction, the historian elucidates, explains, in a Cartesian manner, the succession of events that occurred in time and space. In some historical periods one dared to give these explanations the same objectivity with which one postulates algebraic relations of addition, subtraction, multiplication, division. History came to be visualised as a succession of events that left no remnants, in which, with one event parametrised, one had its modelling on the Cartesian plane.

This positivist, realist conception can be found even when the geometric format becomes spiral. We are thinking of dialectics, whether Hegelian or Marxist. There was and still is, in some historical currents, in some currents of knowing and of knowledge, an omnipotent, omnipresent feeling. The specialist knows everything in their area. They are no longer a man, nor a hero; possessing the knowledge of their speciality and the linearity of their knowledge, they are god. Imbued with a knowledge that can be modelled on the Cartesian plane, they give answers to everything that can be asked (Kant).

At this spiral moment, and not only in it, historians looked at time as being capable of elucidating, clearly and distinctly, the events of the past, and of foreseeing, determining, anticipating, controlling future events. This clarity is better evidenced both in the positivist motto: “to know in order to foresee, to foresee in order to know”, and in the class struggle as the “engine of history” and the union of workers as revolutionary insurgency for the alteration of exploitation. As regards the rationality of historical events—idealists, positivists and Marxists were all enlightened, too humanly so.

Beyond a society that trains specialists, it should be clear to any historian the similarities between the positivist historiographical interpretation and Newtonian mechanicism. The clear, rational, triumphant, Apollonian understanding that, in this historiography, the narrative is structured that control was achieved over the principles of causality that govern the world.

In these same dialogues one can observe the correlation between Hegelian rationality and the electromagnetism of James Clerk Maxwell (1831-1879). In this relationship there is an omnipotence of reason hitherto unseen. In that historical period (nineteenth century), which endures still in many mentalities, a certainty is edified that there was nothing more to be discovered, to be known. The apex of knowledge had already been reached. They dominated magnetism, electromagnetism, and with this everything that could be known.

The historical movements were already registered, and for the next steps there was no space for the new, the different, the unusual. The European man of the nineteenth century

had control of his modes of production, of his consumer goods, of his relations. In a way, looking back, it becomes clear that they did not understand what dialectics is. And it is in this lack of understanding and within this myopia that non-Euclidean geometries arise, and alongside them new time-existential modellings.

Time becomes place, transforms itself into space and engenders new rhythms, new possibilities. The third and fourth forces are unveiled, observed, researched, as are the fourth and fifth dimensions. The infinite, whether in its macro appeal, or in its micro appeal, “returns”, haunting minds, hearts, imaginaries, perspectives, understandings. The openings of possibilities of the imaginary widen fields and spaces in the most diverse areas of knowledge. And here it is in fact interesting, because time can be observed not as a straight line whose direction is evolution. Time acquires variables and takes up again thinkers, ideas, postulates that had already been forgotten.

This thematic historiography becomes atemporal. The units come to be given by the problematics experienced. It is thus that returning to the past, going to the present, drawing the future, is one and the same movement of recognition for those who thought their time. This is the tragic circularity of Nietzsche, who, even in the nineteenth century, was dialoguing with the twentieth, the twenty-first, and the tragic philosophers of the sixth century BC. It is the same circularity that allowed and allows us to bring together Morin and Bachelard.

So that, if at a first moment we glimpse a time of Apollonian characteristics, in its direct, objective and linear causal relationships; at a second moment, we behold a Dionysian time (SANTOS, 2021). Almost a non-time, since its displacement occurs in a zigzag, observing the historiography of science from a biological perspective (FLECK 1986), in a discontinuous manner, with a thematic character.

A theme that arises, emerges as a phenomenon from the relationship, from the circumstances of the problems faced (Bachelard) and at times is emptied, loses interest, does not attain the consolidations for a normal science (KHUN 1997). This non-time produces other geometries and systematisations that break the linear structure. I shall draw upon Conde and Jeferson for an approximation to these ideations, although the professors are weaving a narrative that does not depart from our ideations of the moment:

One then came to attempt to understand the process of the establishment of scientific facts, of how the acceptance of these and of the theories that were founded upon them was negotiated. What this approach revealed was that these two aspects of negotiation—the factual and the interpretative—were simultaneous and circular: the conclusions giving form to the descriptions of the facts, and these constituting the conclusions drawn from them. The circularity evidenced showed, among other things, how fragile was the weight given to experiments in the determination of their results,

and how scientific interpretations and conclusions depend on contingencies and on non-rational factors. (OLIVEIRA E CONDE, 2002, p. 4)

It is here, at one and the same time, that we enter into psychologism and seek to go beyond it. We enter by bringing the genius of Freud in parametrising the internal, private states of subjects, while at the same time decoding aspects of the mind regarded as linguistically non-existent. We seek to go beyond, because this revolutionary notation of Freud adopts a mechanistic-Cartesian model of Euclidean notation, that is, absolute, universal, linear. A model of an atomic self that progressively pulverises in the face of new clinical, physical, mathematical and social observations.

4 THIRD ITINERARY: INTERNAL CARTOGRAPHY, THE DISSOLUTION OF THE ABSOLUTE SELF, SUBJECTIVE TIME

Mathematics is the mother of all figured thought. It permeates and structures constructions. In part, it is the Platonic eidos derived from the Pythagoreans. That essence which gives form to the world, to things, to being. The amusingly strange thing about this construction is that this ipseity is the characterisation of Philosophy. Is Philosophy, then, a mathematics?

For example, zoology studies animals, astronomy, celestial bodies; what does mathematics study? The obvious answer: mathematics deals with numbers, figures, and other abstract objects of the kind; more than a solution, it is a source of new questionings, for what, after all, are numbers, figures and other mathematical objects; what reality should one attribute to them, are they mere inventions of ours or do they exist independently of us and, if so, what place do they inhabit, since they are spatio-temporal objects. In general, what kind of object is an abstract object of mathematics? (SILVA, 2007, p. 14)

Professor Jairo's questioning is very similar to that which Maura Iglesias addresses in her chapter—"What is Philosophy and what is it for".

(...) perhaps it is possible to say and to understand what physics is, from outside physics; and to say what chemistry is, from outside chemistry. But, in order to say and to understand what philosophy is, it is necessary to be within it. "What is physics" is not a physical question, "what is chemistry" is not a chemical question, but "what is philosophy" is already a philosophical question—and perhaps one of the characteristics of the philosophical question is the fact that its answers, or attempts at answers, never exhaust the question, which thus remains with its force as a question, inviting other people and other possible approaches. (IGLÉSIAS, 1986, p. 12)

Philosophy, in this conception, is a pointing, a doing, as Heidegger emphasised. In this pointing, the clearing opens up, the opening is created in which we situate ourselves. A

clearing, an opening in which the tragic philosophers believed that yes, philosophy is a mathematics. Or, not only mathematics, it is also Physis, Bios, Metaphysics.

It is physis both in its appeal of essence, and as natural laws, and also as the physical world, that is, the totality of the mineral, vegetable, animal kingdoms; natura that approaches biology. Bios that in its opening narrows the dialogue with complex thinking.

It is in complexity that life happens. It is in life as concrete existence that the parts unveil the whole and the whole reveals the parts. It is in existentiality that beautiful, plausible, real abstractions, as mathematical, abstract objects, such as a thousand-sided polygon, or a perfect circle, or mountains of gold, are not found in reality, although they fit into language, into the mind, as Bachelard warns us: "It is upon the immutable character of the architecture of geometry that Kant founds the architectonic of reason. If geometry divides, Kantianism can only be saved by inscribing the principles of division in reason itself, that is, by opening up rationalism". (Bachelard, 1968, p. 26)

Sigmund Freud (1856-1939), in his elaboration of the human psyche, draws upon a Cartesian-Kantian matrix with a thermodynamic model of fluids.

Thermodynamics is the branch of the physical sciences that deals with various phenomena of energy and the properties of matter related to it, especially the laws of the transfer of heat into other forms of energy and vice versa. (UFPEI, 2022)

Energy in Freudian theory is understood as libido. Its functioning will be analogous to that of fluids. By fluids one understands: "a substance that deforms continuously, that is, flows, under the action of a tangential force, however small it may be." (GOMES, 2022).

This deformation, flow, force and tangential action will receive the characters of drives, manifesting in each of the phases of the subject's development. A certain lack or excess of flow in a phase tends to entail x, y, z situations.

However improbable it may seem, Freud, in his search for a scientific psychology, models a conception of mind, neurophysiological, but observing that a significant part of hysteria was not of a physiological order, but of a libidinal one. Let us read a little more:

Any resemblance of this mechanistic supposition to the underlying ideas of the "Project for a Scientific Psychology" (1895/1976c) is not mere coincidence. Considered by Freud one of his "idols", Helmholtz founded, together with other physicists and physiologists, among whom E. Brücke, Freud's teacher and master, the scientific movement that would bear his name—the Helmholtz School of Medicine—whose programme consisted in applying physico-chemical postulates to the living organism (Jones, 1953). Now, the "Project" avowedly aims to project into the psyche suppositions of the hard sciences of Freud's time, well in line with the programme that Binswanger qualified as reductionist. The historian of psychoanalysis, Andersson

(2000), nevertheless points out that the Helmholtz School was part of an innovative tendency, which reoriented medical research from anatomy to physiology, from the until then over-valued attempt at anatomical localisation of mental illnesses towards the study of the functions of the nervous system, researched by means of electrophysiology. For the author, this new approach would have allowed Freud to undo the confusion between organic paralysis and hysterical paralysis, a distinction which even Charcot proved incapable of making, because he was still caught up in the old localisationist paradigm. (VIDAL, 2009, p. 270)

Freud, at the end of the nineteenth century and the beginning of the twentieth century, widens and deepens our worldview, “however” his modelling of the psychic apparatus is still Kantian, that is, Newtonian. The criticism we make is not of the father of psychoanalysis, one of the great pioneers of human subjectivity. The criticism is of the part of his followers who incur in an absolute model of mind, of a universal psychic apparatus, almost a century later and in opposition to many advances and scientific models.

Two dissents within psychoanalysis are very emblematic for this exemplification. First, that of Wilhem Reich (1897-1957) who, deepening the dynamics of the libido, unveils the energy of the orgone and opens the doors to bioenergetics. Freudian followers saw, and many continue to see, in this Reichian sharpening an aberration and a decharacterisation of the original Freudian theory. The emblematic thing is that Reich literally touches the G-spot of psychoanalytic theory.

The second is Carl Gustav Jung (1875-1961) who, precisely, contrary to a very reductionist interpretation of libido as genitality, opens up to new themes of understanding, such as, for example, the observation of non-causal components in this psychic structuring. These observations lead him to develop the idea of archetypes, a collective model of some individual patterns, and the concept of synchronicity. This concept, elaborated alongside fruitful dialogues with Wolfgang Pauli (1900-1958), known as “the conscience of physics” due to his perfectionism and meticulousness in verifying the epistemology of his own works and those of colleagues.

With Jung, Pauli was no different, which helped the thinker of archetypes to structure his research on the field of quantum physics that was “being born” at that time. Again, emblematic, because Jung ‘sublimates’ psychoanalysis from almost all genital content and is repudiated just as Reich was, who sharpens it around the sexual question. In any case, both, Reich and Jung, were already observing, both as experience and as theoretical elaboration, that the cellar which the master of Vienna opened unveiled more rooms and possibilities than thermodynamics indicated. There was ‘dissipation’ and flow of fluids to areas, fields, regions far beyond those mapped.

By this we wish to say that the influence of Physics in the fields of psychic modelling is latent and evident. Nevertheless, if the criticisms and elaborations of the father of psychoanalysis were predominantly made on his approximation to the project of making a scientific psychology, that is, reductionist and mechanistic. A model that continues to think subjectivity structured in a Cartesian self, drawing upon a plane geometry of these mental spaces. Thinkers such as Rorty developed their criticisms in a paradox, which I have tried to sketch, briefly, in expounding Reich and Jung, or, on the one hand, mechanistic reduction, on the other, the unconscious.

Through mechanistic reduction, Reich proved the orgone, expanding the concept of sexuality and genitality almost to a return to infinity, an amorphous, indefinite substance that permeates all things. On the other hand, entering into the unconscious and “fleeing” from this sexuality, Jung enters into archetypes, the collective unconscious, basically sublimating psychoanalysis. In general, by mechanistic reduction, read both the project of science and thermodynamics (libido, genitality).

Through the unconscious, one understands one of the greatest hermeneutic projects of humanity in presenting this cellar as being a surrealist architecture. Yes, the Freudian construction is of a stunning beauty. He builds it from the Kantian fields, that is, in the synthetic a priori judgements, he decodes an architecture whose language we were illiterate in. If Descartes opens up the dimensions of the cogito. Kant is the one who models our subjectivity. Yet it is Freud who deciphers a cartography of this space and especially touches one, which had many names and representations, and which he called the unconscious. This space, this place, he saw was not local, it could not be.

The hysteria that he examined physiologically, pointwise, genitally, led him to another place. The hysterical patients showed direct improvements, catharses and reliefs upon being touched; later, he develops listening as another form of touch, generating mentally relieving catharses.

More than a scientific project, psychoanalysis has a whole revolutionary character. In speaking of sex, pleasure, desire in a Victorian society, it liberates minds and imaginaries; yet, dialectically, it ends up keeping the address of being merely the place of this speech and not of this act.

The mind-body division that Reich broke, psychoanalysts, in many of their therapeutic processes, safeguard the conservative place of the body. Enjoyment is a mental delight, a male possibility, not very recommendable for women. There is a chauvinist repression within psychoanalysis, today openly combated by women psychoanalysts.

In spite of this, the unfolding of this image, from the concept of transference, is a hygienist posture in which the psychoanalyst safeguards himself from touch, from contact, with the impurities, read, desires of his patients, more precisely, of his female patients. It is through this focus that we unfold the restrictions placed upon the Reichian discoveries as regards touch and the confirmations that energetic dissipation is also corporeal and not merely mental, psychic. Reich showed that the body without armour, male or female, is free, does not respond to family, state, husband, wife. The sexual revolution of the 1960s runs through the Reichian retrieval and rediscovery.

But, returning, Freud, like few, had clarity about these infinite, dystopian, eruptive, oneiric, fantastical, circular spaces. Nonetheless, as a man of his time, he had an obstinacy in doing science. Normal science (Kuhn). In this undertaking, he draws upon the thermodynamics of fluids. Again, nothing more natural.

The criticism is that, from this hermeneutic construction in its most symbolic and significant appeals, psychoanalysis ends up being elevated to a psychiatric, psychological language of linear parametrisation, with the intention of decreeing what is or is not normal. What is or is not illness. Who is imputable or non-imputable. What is madness or sanity.

For our part, we shall insist on the Bachelardian geometric annotations, and here we move towards the final considerations. Considerations that present theoretical and practical conceptions beyond the Euclidean parallels, that is, through a single point it is possible to pass innumerable straight lines, provided we transpose our gaze from the plane to the existential. Or more directly: psychoanalysis became a model of mind, of psyche, that serves as a seminal orientation for other formulations, but will it be the only one? Could it be that all minds, all psychic structures, would have this matrix? It seems to us not. Could this model be falsified, as Popper proposed?

5 FINAL CONSIDERATIONS

It seems evident to us that, by breaking the Cartesian perceptions, one deconstructs Kantian perspectives, and with this the human sciences can narrow richer dialogues with the matrices of the hard sciences.

We do not think of these dialogues under the aegis of the realist, positivist, that took hold of philosophical thought in the middle of the twentieth century. The dialogue that we think of is in the moulds that Bachelard ends up developing, a poetics, an encounter. In this perspective, it seems clear to us that, by deconstructing the cogito, widening Euclidean geometry, we have thousands of possibilities of mental spaces, of other subjectivities, and not only one, as is Kantianly presumed. Various bodies of knowledge have postulated and

presented these new mental spaces, these diverse architectures, not only in their neural, synaptic bases.

But, to touch this point also requires the courage to deal with the part that escapes reason, the part that transcends the demarcation of limits. The part that, even if we close our eyes, makes itself present and life; the nothing.

The nothing is precisely rejected by science and abandoned as an annihilating element. And when, thus, we abandon the nothing, do we not precisely then admit it? But can we speak of admitting something, if we admit nothing? (...) Against this, science must now affirm anew its seriousness and sobriety: it occupies itself solely with beings. The nothing—what else could it be for science but horror and phantasmagoria? If science is right, then one thing is indisputable: science wishes to know nothing of the nothing; this is, after all, the rigorous scientific conception of the nothing. We know of it, inasmuch as of it, of the nothing, we wish to know nothing. Science wishes to know nothing of the nothing. But it is no less certain, too, that, precisely there, where it seeks to express its own essence, it resorts to the nothing. That which it rejects, it takes into consideration. What ambivalent essence reveals itself there? When we reflect on our present existence—as an existence determined by science—we arrive at a paradox. Through this paradox an interrogation has already been developed. The question requires only an adequate formulation: What happens with this nothing? (HEIDEGGER, 1983, p. 36)

“What happens with this nothing” is the interdisciplinary complexity that casts us into the facticity of existence. “What happens with this nothing” is the question that founds philosophical thought, that is, thinking death, dialoguing with the finitude in which we are experientially placed and inserted. It is in the field of finitude that Philosophy embraces Medicine, referring us to existence, in what it has of the most latent and poignant.

It is in existence that Clinical Philosophy is realised. It is in existence that one seeks to welcome the other in their pains, anguishes, fragilities, disencounters, restlessness. It is in this non-place of the loss of health, of fragility, of illness, of death, that life, living well, begins:

We must accept our existence in all its scope; everything, even the unheard-of, must be possible within it. At bottom, this is the only courage demanded of us: to be courageous in the face of what is most strange, most marvellous and most inexplicable among everything we encounter. (RILKE APUD ARANTES, p. 59)

It is in concrete existence, in four-dimensionality, that other existential logics, that other non-Euclidean geometries, make themselves real. In other terms, in mental abstraction, everything can exist and acquire existence. In the consulting room one observes real fears, real prisons of thoughts as dense and concrete as bars of titanium. These mental constructs are not the motive of our criticism, on the contrary.

The Platonic worlds, the formal creations, mental constructivism, are an entity which the therapeutic proposals propose to investigate. But, is it possible to investigate without resorting to terms that disqualify those who perceive in a different way? Is it possible to investigate phenomena without thereby indexing the other? Labelling them, stigmatising them?

Clinical philosophy believes that it is; yet, more than a belief, it is urgent that there be discussion as to upon which theoretical, physical, philosophical bases and frameworks these systems and our way of seeing the other, of reading the world, are supported. Works by innumerable serious researchers throughout the world have been pointing to clearings that surpass the vision and the psychic model that we possessed (GROFF 1995; DAMÁSIO 1996; SACKS 2007; HART 2014). This is to speak of 4 researchers from distinct areas who have been developing works that lead perceptions to other spheres of understanding, invariably humanising people, expanding conceptual and epistemological limits.

Auditory hallucination, notably classified as symptoms of schizophrenia, in the analyses of Oliver Sacks, in the prism of neurology, casts new gazes upon the understanding of the phenomenon. Researchers such as Stanislav and Cristina Groff, still on the same processes of hallucinations, classifications, labellings, diagnoses, also contribute to a more humanised gaze upon the same phenomenon. Under the aegis of another culture, how would this phenomenon be and is it understood? Could it be that there is only one way to interpret the phenomena of the mind? Could it be that the ailments of the brain must be interpreted as a disqualification of the perceptions of subjects? Grof, Hart, Damásio and innumerable others, even within anti-psychiatry (Laing, Cooper, Szasz), point out that they should not.

They reconfigure time-spatial understandings as not being absolute. They make the phenomenological, hermeneutic adjustment, explaining that one thing is the observation of the stars, of the atoms, transforming them into objects. Another thing is the application of this logic to living beings.

In life (bios), in existence, although everything may still be reduced to natural phenomena (physis), the limits of reason need to be placed. And, incredibly, in these epistemological and methodological foundations, these demarcations are not criticised. Human beings, animals, the ecosystem are elevated to the condition of objects, of patients, and in them they remain in spite of their own thinking and perceiving, without ever returning to the condition of subjects, of persons.

The areas of knowledge, in their realist, objectivist metrics, under the parameter of a conception of modern physics, labelled and stigmatised bodies, worlds and minds, divided the human and life into specialities. As much as we may seek a neurologist, or a cardiologist,

or a psychologist, or a clinical philosopher, the person is not only a mind, or a heart, or a psi field, or an intellectual mesh. The person is all of this and several other things, beings, states.

It is this complexity that transcends the Cartesian plane. It is in it, but also beyond it. A beyond that does not make itself metaphysical. At least, not in the traditional, classical sense. All this overflowing, all this figured is Physics, in the sense of being world and of the world. Not a closed world, but an open world in which beings erupt the stipulated, classified, stereotyped, labelled quadrants. They are situated in them, but should not be determined by them.

It is in the flight from these postulates that non-Euclidean geometries widen new paradigms, not only physico-mathematical, but also social, psychic, medical. It opens up to the perception of the person as a whole, even when one of their parts is examined. An opening that directs us to singularity.

To see each being as human (universal) and singular (person), a dimension very well illustrated by Levinas in the figure of the face. An image very dear to CP, because it is philosophy and clinic. It is the field of abstract objects, just as it is the locus of experiential practice. It is in this correlation that it becomes complex thinking (Morin), open (Bachelard), perspectivist (Nietzsche). In going to the world of the other, it strips itself of itself.

The mental movements of the geometer fall silent, in order to approach the world of the other without pre-judgements, conceived and anticipated truths; clinique. The etymological meaning of the word refers to inclining oneself in the direction of the bed. And in this inclination there is the complementarity of philosophical practice, at least of one of them, the clinic.

It is no exaggeration to say that the ethical science of Sócrates, which occupies the centre of the dispute in the Platonic dialogues, could not have been conceived without the model of medicine, to which Sócrates refers so frequently. Medicine was more akin to him than any other branch of human knowledge then known, including mathematics and the natural sciences. (REALE 1990: 115)

The Socratic praxis in its ethical derivations is born of this relationship with medicine, beginning with his mother; a midwife. This praxis is a doing. An aid in the birthing of ideas, an accompanying of the other's process. There was no ultrasound, the sex of the child was not known before it came to light; one suspects, one intuit, one gets it right, but one does not know. These limits have always been clear and intermingled. So that one does not become pregnant for another, neither does one give birth for anyone, yet it is possible to be alongside, assisting in every sense. It is the dimension of care.

The idea of a speculative philosophy is Platonic. The idea of elaborating ideas and getting lost in these elaborations to the point of separating body from mind is the fruit of the Platonic, Apollonian exacerbation. There is no metaphysics more obsessed than thinkers thinking about the thought of what the other thought, without any correlation with the problem, the birth, the pregnancy, the pain, life, light.

These distinctions progressively separated the bodies of knowledge, dividing the person into various quadrants; yet there was a medicine whose practice was to listen. A listening that had no ready-made truths, only approximations to be carried out, and from this encounter with the other to present solutions. Solutions whose meaning was made and given according to the given conditions, again, it was not an a priori. We are speaking of a knowledge that did not fear not knowing, did not fear not having ready-made answers, all the more so because the answers were woven, elaborated in contact.

Obviously the physician knew, but he knew that he did not know and had no fear of this void. Today everyone knows. There is no space for doubts, for not knowing. All specialists are a kind of gods who answer everything, except the central questions: finitude, death. Death is concealed and in the process a normalised, infantile society is generated by not accepting the only concrete limit—in the end, one dies. And one does not know when. At times, not even why. One dies whether life has been brief, or long, whether one has found and given meaning to one's own life, or not.

It is in this place that knowledge becomes authentic, in the attempt to help in meaning, in care. Far from losing hope, it is this finitude that opens the doors to the infinite and to transcendence. Not only in the mystical sphere, but in the sphere of a more possible human doing. Thus the palliative care physician Ana Cláudia tells us:

The physicians prophesy: "There is nothing more to be done." But, I have discovered that this is not true. There may be no treatments available for the illness, but there is much more to be done for the person who has the illness. (...) I think that every physician should be prepared never to abandon their patient, but in medical school we learn only not to abandon their illness. When there are no more treatments for the illness, it is as if we no longer had the conditions to be alongside the patient. (Arantes, 2019, p. 44-45)

Clinical philosophy is also one of these areas that refuses to accept that there is nothing more to be done. It refuses to reduce the person to their diagnoses. It refuses to accept that there is only one form of mind. It refuses not to deal with existence in what it has of life and death. Clinical philosophy inclines towards the person and asks them to tell their historicity.

All this movement takes place because, even being a philosopher, having done a postgraduate course that flirts with anthropology, mathematics, physics, chemistry, neurology, geography, psychiatry, pharmacology; nothing is known about the other before us, this “infinitely other”, this completely unknown.

The universality of the recognition of this other is an objective fact, yet it only becomes existential concreteness when the clinical philosopher empties himself in order to reach the singularity of the one who shows himself. Yes, there are two basic a priori in CP: one is that we cannot do violence to the human being; two, that singularity is the identity of the human being. In this way, one does not possess a privileged access to the other, given by any of the bodies of knowledge, by any universal point. They served until then, but from that encounter onwards, new elaborations are necessary.

Sócrates's mother attended hundreds of births, but all that knowledge was emptied in order to perform the next one. The next birth was singular to the woman giving birth, even if it were the first or tenth child. It was singular to the midwife, because she had never been there in those conditions to perform that event. This phenomenon that is the same, but other. This event that is other, but is repeated as singular, is the tragic component of the eternal return. It is the call to the ethical responsibility of taking responsibility for that moment as if it were going to repeat itself throughout all eternity.

It is in this elaboration that we speak of structure of thought. More than everything that inhabits the sharer (the one who shares their historicity with us) is their existential architecture. An architecture that is edified in consonance with their categorial bases (circumstance, time, place, relationship), transfiguring itself into their modes of being, into their way of acting, responding, dealing with life.

This architectonic structuring does not allow us to determine anything, nor to prejudge anything. Still less to label anyone. This intellectual mesh is fluid, malleable, and knowing this, the clinical philosopher welcomes their sharer. They welcome, understanding that depression may have been, for that person, the salvation of their life, that mood oscillation is the inherent way of that person being in the world, that there is no normal, single way to exist, and that one should not place people in this existential mould.

Existence, in its biological, physical appeals, insists on showing us that everything is singular. Thousands of species, billions of beings, and the existential complexity is that, even being similar, we are singular. So, how to do the human sciences? How to do the medical sciences?

Our wager is for approximation just as in mathematical Physics. It is in the stipulation of non-being that one qualifies being. It is in the flirtation with death that we qualify life. It is

here that the welcoming in the theme of finitude takes place. Yes, one dies, one comes to an end, one ceases, one becomes ill. And, far from this being treated and thought of as depressive, as anguishing, this is the motive of Philosophy. This is the field of existence.

It is in the search for thinking existing, for welcoming existence, for understanding that we do not have a single and absolute model of being, that clinical philosophy dialogues not with physics, mathematics, medicine, but rather with life, with time. In the best ancient and classical tradition, as Galeno reminds us: "He who is a true physician is always a philosopher." Galeno. (REALE 1990: 364).

To dialogue with time should be the primacy of every area of knowledge. To deal with finitude is similar to the Nietzschean experiment in the face of the abyss; at a certain moment, it looks at you and enters into all your spaces. At this hour it is clear the perception that we are not only straight lines, we have curves, thousands of them crossing a single point and drawing complex, marvellous architectures. But, to face both the infinite and finitude demands humility. The humility of knowing. The humility of knowing that one does not know everything, however much one may know. The humility of asking and of accepting answers from other areas. The humility of accepting that time, the infinite, life, are indecipherable, even though we may decode them.

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EXTRAPULMONARY TUBERCULOSIS IN HEMODIALYSIS PATIENTS: DELAYED DIAGNOSIS AND PROGRESSION TO PARAPLEGIA - EXPERIENCE REPORT

TUBERCULOSE EXTRAPULMONAR NO PACIENTE EM HEMODIÁLISE: ATRASSO DE DIAGNÓSTICO E EVOLUÇÃO PARA PARAPLEGIA- RELATO DE EXPERIÊNCIA

TUBERCULOSIS EXTRAPULMONAR EN PACIENTES EN HEMODIÁLISIS: DIAGNÓSTICO TARDÍO Y PROGRESIÓN A PARAPLEJIA - INFORME DE EXPERIENCIA



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ABSTRACT

Chronic kidney disease, characterised by a set of pathological abnormalities in the kidneys, is characterised by the accumulation of waste in the blood. Tuberculosis in patients with chronic renal insufficiency presents more frequently in the extrapulmonary form, being the predominant infection in the first 12 months of haemodialytic treatment. The aim of this study was to report a singular clinical experience of care for patients diagnosed with infectious spondylodiscitis in the intervertebral disc caused by Mycobacterium tuberculosis and to discuss the impacts generated to the patient when diagnosis is not made at the appropriate time and the implications for nursing. This is a descriptive observational study, an experience report (ER) type, based on theoretical references that discuss the clinical diagnosis and care management for this pathological condition not so present in clinical practice. Adults present gradually with fever, anorexia, weight loss, malaise, fatigue, and most importantly, complaints of chronic pain, low back pain, pain on local palpation, significant limitation of movement and muscle spasms. The presence of spinal cord compression associated with infectious collection reinforces the severity of the condition, in addition to evidencing the importance of early investigation in patients with risk factors. Although manifestations such as pain are frequently present in this group, its trivialisation may result in the neglect of potentially serious conditions. It results in a rare disease, with few structured studies in the literature. It is essential to expand studies and greater discussions on the subject.

Keywords: Spondylodiscitis. Haemodialysis. Extrapulmonary Tuberculosis.

RESUMO

A doença renal crônica, caracterizada por um conjunto de anomalias patológicas nos rins, caracterizada pelo acúmulo de resíduos no sangue. A tuberculose em pacientes com

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insuficiência renal crônica apresenta-se mais frequentemente na forma extrapulmonar, sendo a infecção predominante nos primeiros 12 meses de tratamento hemodialítico. O objetivo deste estudo foi relatar uma experiência clínica singular da assistência aos pacientes com diagnóstico de espondilodiscite infecciosa no disco intervertebral pela *Mycobacterium tuberculosis* e discutir os impactos gerados ao paciente quando o diagnóstico não é realizado no tempo adequado e quais as implicações para a enfermagem. Trata-se de um estudo observacional descritivo, tipo relato de experiência (RE), fundamentando-se em referenciais teóricos que discutem o diagnóstico clínico e manejo de cuidados para essa condição patológica não tão presente na prática clínica. Adultos apresentam de forma gradual febre, anorexia, perda de peso, mal-estar, fadiga, e o principal, à queixa de dor crônica, lombalgia, dor à palpação local, limitação importante de movimentação e espasmos musculares. A presença de compressão medular associada à coleção infecciosa reforça a gravidade do quadro, além de evidenciar a importância da investigação precoce em pacientes com fatores de risco. Embora manifestações como a dor sejam frequentemente presentes nesse grupo, sua banalização pode resultar na negligência de condições potencialmente graves. Resulta-se em uma doença rara, com poucos estudos estruturados na literatura. Fundamental a ampliação de estudos e maiores discussões sobre o tema.

Palavras-chave: Espondilodiscite. Hemodiálise. Tuberculose Extrapulmonar.

RESUMEN

La enfermedad renal crónica, caracterizada por un conjunto de anomalías patológicas en los riñones, se caracteriza por la acumulación de residuos en la sangre. La tuberculosis en pacientes con insuficiencia renal crónica se presenta más frecuentemente en forma extrapulmonar, siendo la infección predominante en los primeros 12 meses del tratamiento de hemodiálisis. El objetivo de este estudio fue reportar una experiencia clínica singular de la atención a pacientes con diagnóstico de espondilodiscitis infecciosa en el disco intervertebral causada por *Mycobacterium tuberculosis* y discutir los impactos generados al paciente cuando el diagnóstico no se realiza en el tiempo adecuado y cuáles son las implicaciones para enfermería. Se trata de un estudio observacional descriptivo, de tipo informe de experiencia (IE), fundamentado en referencias teóricas que discuten el diagnóstico clínico y el manejo de cuidados para esta condición patológica no tan presente en la práctica clínica. Los adultos presentan gradualmente fiebre, anorexia, pérdida de peso, malestar, fatiga, y lo más importante, quejas de dolor crónico, dolor lumbar, dolor a la palpación local, limitación significativa del movimiento y espasmos musculares. La presencia de compresión de la médula espinal asociada con colección infecciosa refuerza la gravedad de la condición, además de evidenciar la importancia de la investigación temprana en pacientes con factores de riesgo. Aunque manifestaciones como el dolor estén frecuentemente presentes en este grupo, su trivialización puede resultar en la negligencia de condiciones potencialmente graves. Resulta en una enfermedad rara, con pocos estudios estructurados en la literatura. Es esencial ampliar los estudios y mayores discusiones sobre el tema.

Palabras clave: Espondilodiscitis. Hemodiálisis. Tuberculosis Extrapulmonar.

1 INTRODUCTION

Chronic Kidney Disease (CKD) is characterised by a set of pathological abnormalities in the kidneys, characterised by the accumulation of waste in the blood. Progressive disease of debilitating and terminal evolution, its aetiology develops from three main factors: senescence, arterial hypertension and Diabetes Mellitus, and once developed, it can still evolve into several other diseases (Ribeiro, 2019).

It is estimated that approximately 850 million people worldwide suffer from kidney disease, with the majority living in low-income countries. A large portion of the population still does not have adequate access to diagnosis, prevention or treatment of this condition (Jager *et al.*, 2019). By 2040, the disease could be the fifth leading cause of death in the world (Foreman *et al.*, 2018).

Patients undergoing haemodialysis (HD) have a risk of developing tuberculosis (TB) 6.9 to 52.5 times higher than the general population, this is because CKD patients are immunosuppressed, as uraemia is associated with reduced expression of glycoprotein costimulators on antigen-presenting cells. There is malnutrition, zinc deficiency, vitamin D, in addition to impaired phagocytic, migratory and chemotactic function, resulting in lower capacity to eliminate microorganisms (Fonseca *et al.*, 2013; Lundin *et al.*, 1979; Santos *et al.*, 2025).

The authors associate the presence of bone tuberculosis in patients with CKD with immune dysfunction, characterised by relative immunosuppression and alterations in the inflammatory response. Such a condition may imply a higher risk of unfavourable evolution, greater morbidity, diagnostic delay (often attributed to the renal conditions themselves) and greater complexity in pharmacological management, especially due to the increased risk of drug toxicity (Ferreira *et al.*, 2021).

2 THEORETICAL BACKGROUND

According to *Guidelines Kidney Disease: Improving Global Outcomes* (KDIGO), CKD is defined as a structural or functional alteration in the kidney for at least 3 months, causing implications for health. It is classified through glomerular filtration rate (GFR) in stage V, less than 15 ml/min/1.73m² and albumin levels in the body (*Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease*, 2024).

Kidney disease increases the risk of mortality, morbidity and disability, as well as reducing quality of life. It brings significant economic consequences for individuals and health systems, as well as causing significant environmental impacts (Francis *et al.*, 2024).

CKD is considered the third fastest-growing cause of death in the world, being the only one among non-communicable chronic diseases showing a continuous increase in age-adjusted mortality (Wang *et al.*, 2016).

Given this reality, the patient undergoing renal replacement therapy by HD faces changes in their daily life, encompassing social, occupational, dietary and sexual life aspects which directly impact their physical and mental integrity. Such changes contribute to increased vulnerability and to the impairment of quality of life (Ferreira; Silva Filho, 2011; Francis *et al.*, 2024).

With this, frailty syndrome stands out, a condition of clinical and multifactorial nature, characterised by greater susceptibility to stressors, associated with reduction of physiological reserve, muscle strength and functional capacity. As a consequence, there is greater risk of dependence, hospitalisations, functional decline, as well as increased morbidity and mortality (Gesualdo *et al.*, 2020).

The World Health Organization (WHO) points out that TB has returned to its position as the leading cause of death from an infectious agent in the world, despite being a preventable and treatable disease, even surpassing the mortality rates previously attributed to Covid-19 (WHO, 2025).

Between 2022 and 2023, an increase of 3% in mortality from the disease was observed in Brazil, with the rate reaching 2.8 deaths per 100,000 inhabitants in 2023. In 2024, newly registered cases increased by 21%, totalling 84,308 notifications (Brasil, 2025).

Looking at developing countries, the diagnosis of extrapulmonary tuberculosis faces significant challenges, mainly related to limited infrastructure of health services and technical lack of knowledge. Adding to this is the presence of non-specific clinical signs, which vary according to the anatomical location of the disease, as well as the frequent absence of concomitant pulmonary involvement. The unavailability or difficulty of access to specific examinations, such as bacilloscopy, biopsy and molecular and bacteriological tests, contributes to diagnostic delays, favouring underdiagnosis and underreporting of cases (Farer; Lowell; Meador, 1979; Florencia, 2024; Queiroz, 2008).

Within this panorama, tuberculous spondylodiscitis (TS) emerges as a relevant extrapulmonary manifestation. It is characterised as an infectious process affecting the spine, affecting vertebral bodies and adjacent paravertebral structures, which can lead to the formation of abscesses and bone involvement (Conti *et al.*, 2025a).

The origin of the infection can be classified as endogenous or exogenous. The endogenous form is preceded by a primary infectious focus distant from the vertebral bodies, with haematogenous dissemination and subsequent colonisation of the spine. Frequently, at

the time of diagnosis of spondylodiscitis, the initial focus is no longer identified. The exogenous form is related to invasive procedures performed in regions close to the spine (Herren *et al.*, 2017).

It is a condition of high morbidity, associated with important neurological sequelae, frequently accompanied by chronic low back or thoracic pain. Despite being infrequent, its incidence has increased in recent decades, due to the increase in life expectancy, the greater prevalence of chronic diseases, the use of intravenous drugs, immunosuppression, prolonged use of corticosteroids, infection with human immunodeficiency virus (HIV), renal or hepatic failure, as well as the performance of invasive procedures and surgeries (Massabni; Bonini, 2019; Matos Queiroz; Alves De Assis Pereira; Figueiredo, 2013; Ribeira *et al.*, 2008).

The disease affects, more frequently, socially vulnerable populations, which may contribute to its neglect in research and therapeutic aspects. Underdiagnosis favours the occurrence of irreversible neurological sequelae and implies high-cost treatments, including prolonged antibiotic therapy, long periods of hospital stay, invasive investigations and, in some cases, surgical approach (Ferreira *et al.*, 2021).

Clinically, the evolution of TS is marked by a mixture of neurological, systemic and orthopaedic signs and symptoms, which must be investigated. The onset is usually gradual, a slowly progressing disease, the time between appearance of symptoms and diagnosis is approximately 12 months (Shanmuganathan *et al.*, 2023).

TB in patients with chronic renal failure presents more frequently in the extrapulmonary form, being the predominant infection in the first 12 months of haemodialytic treatment. In the Sant *et al.* study (2004), 1,266 patients with CKD under HD in the municipality of Rio de Janeiro were analysed. Tuberculosis was diagnosed in 2.6% (n=30) of individuals. When compared to the general population of Rio de Janeiro, these patients presented significantly higher prevalence of the disease, with a relative risk of 19.68. There was also a significant predominance of the extrapulmonary form (63.3%; n=19) in relation to the pulmonary form 33.3% (n=11).

A study conducted in Turkey (Turunc *et al.*, 2007) aiming to compare the clinical, laboratory and radiological characteristics of TS, brucellous and pyogenic demonstrated that, among the 75 patients evaluated, 13 presented TS. In this group, a significantly higher frequency of CKD was observed, as well as greater prevalence of general symptoms and manifestations, such as weight loss, night sweats and general malaise.

The systematic review with meta-analysis of (Alemu *et al.*, 2022) was, to date, the first to analyse data from scientific electronic databases, with publications between 2000 and

2021. The study identified 104 observational studies conducted in 32 countries, totalling 1,548,744 patients with CKD, of which 12,189 had TB. The pooled incidence of TB in patients with CKD was estimated at 3,718 cases per 100,000 individuals.

The relevance of the extrapulmonary form of the disease is highlighted, whose incidence was described in 73 studies, with values varying from 50 cases per 100,000 individuals. In the Brazilian context, the number of studies is still limited, with only seven studies identified, with a total of 294 cases identified.

TS, especially when associated with comorbidities such as chronic kidney disease, constitutes a picture of high clinical complexity, marked by persistent pain, progressive functional limitations and greater vulnerability (Alemu *et al.*, 2022)

TB in chronic renal patients has relevant impact at global level, however, still has limitation of studies in the Brazilian context restricting a more thorough understanding of clinical manifestations, which hinder early recognition and contribute to diagnostic delays and worsening of disease evolution and adequate clinical management. Furthermore, tuberculosis should not be understood as a condition restricted to populations in vulnerable situations, but as a possible reality in the daily reality of health services, being liable to be present in any care setting (Luczynski *et al.*, 2023).

This study aims to report a singular clinical experience of the author in the care of patients diagnosed with infectious spondylodiscitis in the intervertebral disc caused by *Mycobacterium tuberculosis*, where the evolutions were marked by infectious complications, with surgical re-approaches and acquired sequelae. This report seeks to add value to the literature in the field of nursing, by addressing the challenges of nursing in the face of signs and symptoms, loss of functionality and pain management during the evolution of the disease.

The importance of nursing care in the systematic assessment of pain, in continuous clinical monitoring and in the implementation of interventions aimed at maintaining functionality and preventing complications arising from immobility is highlighted.

3 METHODOLOGY

This study is a descriptive observational study, an experience report (ER) type experienced by the author. As it is purely about the author's own experience, without patient identification and without collection of primary data, this study was not submitted to the ethics and research committee. Ethical principles were respected, ensuring anonymity, confidentiality and secrecy of information.

The ER in academic context aims to record of experiences lived from research, teaching, university extension projects, among others, not necessarily, an academic research report (Mussi; Flores; Almeida, 2021).

The context in which the experience is narrated takes place in an outpatient haemodialysis clinic in the interior of São Paulo state. The reflections on the routine of the institution arose from the author's experience as a nursing graduate in the observation and care of chronic renal patients. The experience was described separately through thematic axes, defined from the most relevant aspects observed, organised in: the routine, the clinical manifestations and the late diagnosis. Furthermore, consultations are carried out in the literature and bibliographic sources to support such observations and lived experience.

The theoretical reference was obtained through studies, systematic reviews, master's dissertations, qualitative research, clinical practice guides that had the full text, in Portuguese and English, with a focus on the last 15 years, through the databases of the BVS (Virtual Health Library), SciELO (*Scientific Electronic Library Online*), MEDLINE (*Medical Literature Analysis and Retrieval System Online*), BDENF (Nursing Database) and LILACS (Latin American and Caribbean Literature in Health Sciences) and CAPES (Coordination for the Improvement of Higher Education Personnel) portal using Descriptors in Health Sciences (DeCS) interspersed with Boolean operators, in Portuguese and English: "Spondylodiscitis AND haemodialysis AND Extrapulmonary tuberculosis".

4 RESULTS

4.1 ROUTINE

The viability of this experience report occurred through the experience of the nursing graduate, from a private university, in spontaneously accompanying the routine service in an outpatient clinic, in the interior of São Paulo state, where they provide care for patients with chronic renal insufficiency dependent on renal replacement therapy, haemodialysis, for the public served by the single health system (SUS), during the period from January 2019 to July 2021.

At the clinic, patients were attended on average three times a week, with a duration of four hours each session, operating Monday to Saturday, with these divided into three shifts during the day, divided into 4 therapy rooms.

Patients were submitted to this therapeutic modality through vascular access, with the presence of the Shiley catheter (emergency situations/temporary), permacath (long duration), or the arteriovenous fistula (AVF) considered the gold standard in choice for chronic patients (Harduin *et al.*, 2023). This vascular access is connected to an invasive machine, which

promotes the filtering of the accumulation of waste in the blood, which the kidneys are unable to eliminate. Patients were subjected each session to pre and post therapy weighing, in order to monitor weight variation and quantify ultrafiltration (UF), aiming at the assessment of interdialytic weight gain and the establishment of targets to achieve dry weight. When patients reached values exceeding weight/liquid, the team itself took responsibility for programming and preparing extra sessions on alternate days for more frequent therapy with less intensity, for the purpose of eliminating the excesses. In interactions with these patients, one identified a maintenance of survival, even with low indices of quality of life (SBN, 2023).

Monthly, patients underwent laboratory examination collection for evaluation of biological markers and reassessment of general status. The exams are calcium, creatinine, phosphorus, glucose, haematocrit, haemoglobin, potassium, sodium, TGP, urea pre and post session, monitoring is performed through these monthly exams in addition to those scheduled semi-annually and annually, according to RDC 154 guidelines. The objective is to detect complications associated with the condition of therapy, such as anaemia, iron deficiency, vitamin B12.

During the substitute therapy sessions, the team creates a strong bond with the patient, discovering and understanding the context of life in which they are inserted, thus knowing the physical, psychological, emotional and social limitations and needs. The patient throughout the therapies created a high bond with the professionals, the environment, the management of care and even among the fellow dialysis colleagues. In the vast majority, patients of low purchasing power, from neighbouring cities, came to the clinic through municipal council transportation, presenting fragility also in the needs of caregivers, who needed to wait for the hours of dialysis, in order to be able to return to their home city.

4.2 CLINICAL MANIFESTATIONS

A progressive impairment of motor function was identified in patients undergoing substitute therapy, which, over sessions and years, becomes increasingly impaired, with a worse prognosis of the clinical picture (Pires *et al.*, 2017).

As the days progressed accompanying the routine, one perceived a painful and long-lasting treatment which, along with the evolution of the disease, has greater complications, being able to highlight: fatigue, nausea, depression, hypotension, muscle spasms, blood clots, infections and allergic reactions (Bennett *et al.*, 2025).

In accordance with the literature, a high index of infectious complications was observed, which could be caused by bacteria, fungi or viruses. Patients presented difficulties in coping with long-duration vascular accesses, care in handling and necessary maintenance,

and in addition, the team has the responsibility with preventive measures, such as hand hygiene and care towards accesses (Katneni; Hedayati, 2007).

During the sessions, some patients presented an increase in pain score, along with other signs and symptoms, the nurse and nursing technicians were the professionals who welcomed, classified and provided care for pain management, which in some cases was not enough to stop the pain crisis. Together with the multidisciplinary team, it was necessary to continue investigations to improve this acute condition. However, during this time the persistence and advancement of the picture was noted, even though it could be influenced by the underlying pathology, there is still a need and obligation for further investigations and continuous reassessments of the picture. In practice, the crisis is often treated as isolated cases, administering intravenous drugs to improve the pain score, showing a generic context, which does not always help to guide the construction of clinical reasoning (Mehrotra *et al.*, 2023).

Patients with chronic pain in haemodialysis are attributed as expected manifestations within the base conditions, thus resulting in a number of patients with underestimated adjacent diseases that cause greater damage to the patient's quality of life (Tavares *et al.*, 2020).

In this entirety, the occurrence of complications associated with bone tuberculosis in immunosuppressed patients, characterised by atypical signs and symptoms and slow evolution, was detected. The infection was related to haematogenous dissemination, resulting in vertebral involvement (Lopes *et al.*, 2023).

4.3 LATE DIAGNOSIS

Delay in investigation leads patients to seek emergency care services, where due to urgency and disease evolution it is necessary to check through magnetic resonance imaging (MRI) and computed tomography (CT) the reason for 'sudden' paraplegia.

Suspicious should be raised by the team at the beginning of investigations, laboratory exams should be analysed to guide the process, some studies bring as an initial follow-up the analysis of erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) values, and for better evaluations the use of radiographic exams of the vertebral body, with magnetic resonance imaging being the best option to identify bone distribution (Rodrigues; Bortoletto; Matsumoto, 2010; Santos *et al.*, 2023a).

The absence of diagnosis in a timely manner contributed to the worsening of the clinical picture, with serious outcomes, long hospitalisations and surgical approach that further compromises the vertebra, in advanced cases there is spinal cord compression by

collection, as well as the emergence of other associated complications that directly impact the quality and maintenance of life. These interventions could have been uncomplicated and non-invasive if the diagnosis were not so late, in this case 10 months of signs and symptoms without adequate conduct, since the patient is welcomed and monitored by the haemodialysis team (Schettino; Carelli; Barbosa, 2010; Tavares *et al.*, 2021).

Complications such as kyphosis, permanent neurological deficits, vertebral canal stenosis, can be reduced with appropriate therapy (Anjos *et al.*, 2024).

Such factors directly impact the prognosis of patients, and may even lead to exclusion from the transplant queue, which in the context of this patient is a setback in a process of liberation from the haemodialysis machine.

TB in chronic renal patients may be more common than the literature brings us, as there is underreporting of cases. This experience in the scenario of increasing morbidity and decline in quality of life, makes professionals not recognise such patterns of pain and functional dependence.

The care experience allowed us to recognise that investigation, early identification, pain pattern are essential both for complications of low to high scale, and that when this conduct is not carried out, the morbidity of patients increases along with mortality.

5 DISCUSSION

Tuberculosis remains an important public health issue worldwide, with the pulmonary form being the most frequent and widely studied, accounting for approximately 95% of cases, whilst extrapulmonary manifestations have scarce and limited national content, with involvement of the thoracolumbar region being one of the main regions of musculoskeletal tissue affected (Rodrigues; Bortoletto; Matsumoto, 2010). The dissemination of the disease can occur via haematogenous, lymphatic or by contiguity from adjacent infectious foci (Rodrigues; Bortoletto; Matsumoto, 2010).

Immunosuppression is defined as the deficiency that the immune system presents in response to aggressive agents; the acquired form (in the case of chronic renal) is due to an external factor that affects the immune system (Garcia *et al.*, 2004). Bloodstream infection in chronic renal patients is one of the main causes of hospitalisation and mortality in this group of patients, after cardiovascular diseases (Harduin *et al.*, 2023).

A retrospective study by Menis *et al.* (2022) analysed 431 patients, over a 5-year period (2016-2021), notifications of bloodstream infection in the haemodialysis sector. Patients using permacath presented 64% notifications of bloodstream infection (BSI),

followed by 34% in cases using double lumen catheter and 1% in patients using arteriovenous fistula (AVF).

Another study by Weldetensae (*et al.*, 2023) from 2016 to 2022, with 353 patients identified 38.2% of catheter-related BSI, with an incidence of 7.74 episodes per 1,000 device-days, the study also revealed that the second main reason for catheter removal was 25.6%, due to infection, second only to renal recovery.

The signs and symptoms of the patient with BSI may be: chills, fever, hypotension, tachycardia, phlogistic signs and even secretions at the insertion site (Andrade; Garcia; Cruz, 2025). The presence of infections evidences the potential for dissemination of infectious agents via haematogenous route. This propagation enables the involvement of secondary sites, with parallel complications such as pain, dyspnoea, low back pain, bone and joint pain being common in patients undergoing haemodialysis (Ribeiro; Jorge; Queiroz, 2020).

According to the World Health Organization, risk factors for tuberculosis are considered to be contact with an active carrier, immunosuppression by cancer, HD, HIV, drug use, Diabetes Mellitus, renal failure, malnutrition (WHO, 2011).

In the case of tuberculosis, the agent *Mycobacterium tuberculosis* can disseminate via haematogenous route, reaching bone and joint structures, characterising the extrapulmonary form of the disease. It manifests itself in various ways, is accompanied by fever, night sweats, spinal rigidity, muscle weakness and alterations in the lower limbs of sensory aspect (Santos *et al.*, 2023b).

Leal and colleagues (Leal *et al.*, 2003) studied 24 patients between one and 78 years old with septic spondylodiscitis. It was identified in their study that 8.3% achieved improvement without complications, while there were 12.5% deaths and among the cure (79.2%) obtained 8.3% neurological deficit. He further reinforces that the factors related to haematogenous spondylodiscitis are: diabetes mellitus, rheumatoid arthritis, use of corticosteroids, intravenous drugs, history of infections, between 20 to 82% of cases, CKD undergoing HD.

Collaborating with this study, the report of Zanatelli *et al.* (Zanatelli; Zanatelli; Galassi, 2013) demonstrates the difficulty in identifying and treating the patient, which at the beginning was interpreted as ischaemic stroke (AVEI), with worsening of the picture and sensory level, was submitted to MRI of the dorsal spine, identifying inflammatory process in disc D7/D8 extending to disc reduction and spinal cord compression. With diagnosis dependent on medical suspicion, delay in discovery and appropriate therapy collaborates for worse outcomes.

Adults present gradually with fever, anorexia, weight loss, malaise, fatigue, and most importantly, complaint of chronic pain in the back, low back pain, pain on local palpation, significant limitation of movement and muscle spasms (Matos Queiroz; Alves De Assis Pereira; Figueiredo, 2013).

A retrospective study by (Ribeira *et al.*, 2008) conducted at Coimbra Hospital Centre, between 2002 and 2007 reviewing clinical records of 28 patients diagnosed with spondylodiscitis observed that the average length of hospital stay was 76.6 days (SD $\pm$ 34.2); most frequent clinical manifestations were pain in (92%) and average duration of pain until diagnosis was assessed in 10 patients and lasted an average of 95 days. Of the patients who presented neurological injury, complete paraplegia in two and incomplete paraplegia in eight patients.

The basis of therapy is anti-TB therapy, with more than 90% success of cases, MS guides the same institution of pulmonary tuberculosis, maintaining the surgical approach to specific cases with precise indications. The recommended scheme is Rifampicin, Isoniazid and Pyrazinamide and Ethambutol (RHZE), being the basic scheme RHZE for 2 months (intensive phase) and RH for 10 months (maintenance phase) (Ministry of Health, 2025).

Corroborating with this experience, the case report of Fonseca *et al.* (2022) presents a patient admitted with a picture of paraplegia, associated with infectious spondylodiscitis and presence of thoracic collection with spinal cord compression. Despite being a young patient, surgical intervention was considered high-risk, with the possibility of maintaining permanent neurological sequelae, exceeding the potential benefits. Given this, it was decided to opt for drug therapy; however, the patient evolved with profound areflexia, muscle strength grade 0 and loss of sensitivity in the lower limbs. These findings evidence the severity of neurological involvement associated with disease progression, especially when diagnosis and intervention occur late.

Comparing with the mentioned study, similar clinical evolution is observed to the present experience, characterised by persistent pain, associated with non-specific signs and symptoms, which contributed to delay in the recognition of the picture and progression of the infection, culminating in the development of serious neurological complications. The presence of spinal cord compression associated with infectious collection reinforces the severity of the condition, as well as evidencing the importance of early investigation in patients with risk factors.

A retrospective study conducted in northern Italy, with data collection between January 2010 and December 2023, analysed the characteristics of infectious spondylodiscitis over 14 years. It was observed that 53 cases (54.1%) had pyogenic bacterial aetiology, 10 cases

(10.2%) were attributed to *Mycobacterium tuberculosis* and 35 (35.7%) presented unknown aetiology. Among patients with TS, 30% were carriers of diabetes mellitus and 20% of CKD. The most frequent symptom was low back pain (90%), followed by fever (90%), whilst only 20% presented neurological signs. It is noteworthy that, in this group, all cases had an initially undetermined origin, with an average time to diagnosis of 35 days (16–60 days), as opposed to other studies, this average time was relatively low (Conti *et al.*, 2025b).

In the experience lived, there was no establishment of diagnosis in a timely manner, even after multiple investigations. The identification of the picture occurred only in the face of a neurological emergency, when imaging exams evidenced spinal cord compression, already associated with the risk of serious complications, such as meningitis. It is noteworthy that the presence of non-specific symptoms favours misinterpretations, frequently attributed to less serious conditions, which contributes to diagnostic delay and disease progression.

6 FINAL CONSIDERATIONS

In this practical experience in tertiary care and with high-complexity care, it was identified how much patients undergoing haemodialysis require comprehensive and holistic care, that adjacent diseases can further compromise the patients' lives. The therapeutic interventions offered to patients undergoing haemodialysis do not guarantee the recovery of quality of life, but rather its maintenance. This experience showed how much patients are fragilised in levels of education, housing, income, understanding of their own disease and in their own self-care. Patients spend long periods subjected to the machine, without effectively understanding their disease, its alterations, the morbidities and their probable risks. The team becomes essential in the process of health education, in physical and emotional support. In accordance with the experience, patients consider treatment anguishing, suffering and painful not only due to the disease, but due to the therapy that becomes the only form of life maintenance. Such observations promoted greater sensitivity and drive to unearth in the literature (mainly national) such atypical findings and that deserve to reach larger proportions, since many of the morbidities presented are masked by the underlying disease. The most important thing is that these are not isolated cases, but sporadically one noticed patients with similar characteristics, but that after discussions, observations, lived experiences and understanding of the severity by the multidisciplinary team, began to be conducted in a differentiated manner, thinking and acting in a more active way. Thus, although this experience represents a small contribution given the complexity of the subject, it is hoped that the lived experiences reported here may encourage new perspectives on patients with similar presentations, stimulating clinical investigation, multidisciplinary action and the

production of scientific knowledge, in order to favour more timely diagnoses and care that is increasingly qualified and humanised.

This study brings as a theme a rare disease, with few structured studies in the literature, being essential to expand studies and greater discussions on the subject. When there is a scarcity of literature to support conduct and care, the difficulty arises in understanding and managing the symptomatology that initially suggest victimisation of the patient. The attention of the multidisciplinary team is important, mainly nursing, being the category that has continuous contact with the patient during haemodialysis sessions, occupying a position of greater coexistence, acting as an important facilitator in the early identification of clinical alterations and in guiding diagnostic investigation.

Finally, it is emphasised that treatment, although often perceived as complex, is, in reality, accessible and well established and made available in the Single Health System. However, therapeutic success does not depend only on the availability of treatment, but, above all, on the careful and qualified view of the professional. In this sense, early diagnosis becomes essential to prevent disease progression, preventing neurological complications, the need for surgical interventions and even fatal outcomes.

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USE OF GLASS FIBRE AND QUARTZ FIBRE POSTS IN THE REHABILITATION OF ENDODONTICALLY TREATED POSTERIOR TEETH: AN INTEGRATIVE REVIEW

UTILIZAÇÃO DE PINOS DE FIBRA DE VIDRO E DE FIBRA DE QUARTZO NA REABILITAÇÃO DE DENTES POSTERIORES TRATADOS ENDODONTICAMENTE: UMA REVISÃO INTEGRATIVA

USO DE ESPIGAS DE FIBRA DE VIDRIO Y DE FIBRA DE CUARZO EN LA REHABILITACIÓN DE DIENTES POSTERIORES TRATADOS ENDODÓNTICAMENTE: UNA REVISIÓN INTEGRATIVA

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ABSTRACT

Dental posts are materials used to provide load support and sustenance to the remaining tooth structure during oral rehabilitation. Their application is usually related to situations in which significant loss of tooth structure occurs, being employed after endodontic treatment, since the post is inserted within the root canal. In this regard, fibre posts are gaining prominence in the market owing to their excellent mechanical and structural properties. The present research aims to compare the fracture resistance of both the glass fibre post and the quartz fibre post in posterior teeth. Searches were carried out in the electronic databases Scielo, PubMed, ScienceDirect and Scopus between the years 2016 and 2026. A total of 1,353 records were found and only 5 articles were selected for meeting the requirements of the research in question. The quartz fibre post has high mechanical resistance, in addition to an elasticity modulus similar to that of dentine, better light transmission, as well as fibre density and orientation providing better force distribution. The glass fibre post, in turn, has high mechanical resistance, an elasticity modulus close to that of dentine, better adhesiveness and homogeneity with the resin. In comparative terms, the results related to

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fracture resistance are satisfactory for both posts, with the quartz post being slightly better regarding resistance; however, no significant difference between the posts was evidenced.

Keywords: Quartz Fibre. Glass Fibre. Dentistry.

RESUMO

Pinos odontológicos são materiais utilizados para proporcionar suporte de carga e sustentação aos remanescentes dentários durante a reabilitação oral. Habitualmente, sua aplicação está relacionada quando ocorre perda significativa da estrutura dentária, sendo empregada posteriormente ao tratamento endodôntico, pois o pino tem sua inserção dentro do canal radicular. Nesse sentido, os pinos de fibra estão ganhando notoriedade no mercado devido às suas excelentes propriedades mecânicas e estruturais. A presente pesquisa tem por objetivo comparar a resistência à fratura tanto do pino de fibra de vidro quanto do pino de fibra de quartzo em dentes posteriores. Realizou-se buscas nas bases de dados eletrônicos Scielo, PubMed, ScienceDirect e Scopus entre os anos de 2016 a 2026. Foram encontrados 1353 e apenas 5 artigos foram selecionados por cumprirem os requisitos da pesquisa em questão. O pino de fibra de quartzo possui uma resistência mecânica elevada, além de módulo de elasticidade semelhante ao da dentina, melhor transmissão da luz, além da densidade e orientação das fibras com uma melhor distribuição das forças. Já o pino de fibra de vidro, possui resistência mecânica elevada, módulo de elasticidade próximo ao da dentina, melhor adesividade e homogeneidade com a resina. De maneira comparativa, os resultados relacionados a resistência à fratura são satisfatórios para ambos os pinos, sendo o pino de quartzo ligeiramente melhor no quesito resistência, entretanto, não foi evidenciado uma diferença significativa entre os pinos.

Palavras-chave: Fibra de Quartzo. Fibra de Vidro. Odontologia.

RESUMEN

Las espigas dentales son materiales utilizados para proporcionar soporte de carga y sostén a los remanentes dentarios durante la rehabilitación oral. Habitualmente, su aplicación está relacionada con situaciones en las que ocurre una pérdida significativa de la estructura dentaria, empleándose posteriormente al tratamiento endodóntico, ya que la espiga se inserta dentro del conducto radicular. En este sentido, las espigas de fibra están ganando notoriedad en el mercado debido a sus excelentes propiedades mecánicas y estructurales. La presente investigación tiene por objetivo comparar la resistencia a la fractura tanto de la espiga de fibra de vidrio como de la espiga de fibra de cuarzo en dientes posteriores. Se realizaron búsquedas en las bases de datos electrónicas Scielo, PubMed, ScienceDirect y Scopus entre los años 2016 y 2026. Se encontraron 1353 registros y solo 5 artículos fueron seleccionados por cumplir los requisitos de la investigación en cuestión. La espiga de fibra de cuarzo posee una resistencia mecánica elevada, además de un módulo de elasticidad similar al de la dentina, mejor transmisión de la luz, así como la densidad y orientación de las fibras con una mejor distribución de las fuerzas. La espiga de fibra de vidrio, por su parte, posee resistencia mecánica elevada, módulo de elasticidad próximo al de la dentina, mejor adhesividad y homogeneidad con la resina. De manera comparativa, los resultados relacionados con la resistencia a la fractura son satisfactorios para ambas espigas, siendo la espiga de cuarzo ligeramente mejor en cuanto a resistencia; sin embargo, no se evidenció una diferencia significativa entre las espigas.

Palabras clave: Fibra de Cuarzo. Fibra de Vidrio. Odontología.

1 INTRODUCTION

Dentistry is the science responsible for the study of the stomatognathic system, analysing its constituent parts such as the mouth, face, joints, jaws, gingiva and tooth. In the oral cavity the dental arch plays a fundamental role, with each tooth being responsible for performing specific functions, which are related to phonetics, aesthetics, mastication and balance in dental occlusion. Posterior teeth (premolars and molars) are known for receiving loads and distributing forces, promoting harmony during mastication (Keçec; Heidemann; Kurnaz, 2016).

In view of this, tooth loss constitutes a problem that must be observed carefully, since the absence of certain teeth, especially posterior ones, may lead to disarrangement of the occlusion and negatively stimulate future problems. Among the “villains” that promote loss in the dentition is caries, a multifactorial and biofilm-dependent disease, which provides extensive tooth destruction. In the rehabilitative scope, from the moment the tooth has total crown impairment, but there being little coronal remnant (around 2 mm), direct rehabilitation with composite resin is no longer viable, owing to the constant fractures in this region (Amritha *et al.*, 2023).

The use of dental posts gained prominence in contemporary oral rehabilitation as a reinforcement structure, which would reduce the risk of dental fracture, it being important to point out that the dental element needs to be endodontically treated to obtain success in the procedure. In former times the process of restoring the dentition was more rudimentary, with the use of gold/metallic alloys and the soldering of crowns with multiple retentions being some of the alternatives proposed during the period (Batra *et al.*, 2022).

With the evolution of dentistry the cast metal core became indispensable for dental treatments, being usable both for anterior and posterior teeth. These cores have positive characteristics such as better area filling, versatility and hardness. However, they present a risk of corrosion, chromatic alterations, longer working time, an elasticity modulus extremely different from that of dentine, being more susceptible to vertical fracture of the tooth. These are disadvantages that accompany the use of this metallic post. Currently, the oral rehabilitation of endodontically treated teeth, with coronal remnant, is performed through the use of fibre posts. The main dental fibre posts are the glass fibre post and the quartz fibre post (Batra *et al.*, 2022).

The former is known in the market for presenting high mechanical resistance, an elasticity modulus similar to that of dentine, better adhesiveness and homogeneity with the resin, in addition to having no risk of corrosion; another important point to highlight is its low cost and high longevity. However, the glass fibre post, in some cases, requires adaptation

within the root, with the anatomisation of the glass fibre post with resin being an alternative that allows its use in these specific situations (Batra *et al.*, 2022; Amritha *et al.* 2023; Meimandinezhad *et al.*, 2023).

The latter, the quartz fibre post, has high mechanical resistance, in addition to an elasticity modulus also similar to that of dentine, better light transmission, as well as the density and orientation of the fibres with better force distribution. The negative points of using the quartz post in question are its lower adaptation in canals with irregular anatomy, alteration of mechanical property if the surface is not well treated, and the fact that good adhesiveness is related to the correct use of the technique (Meimandinezhad *et al.*, 2023).

It is worth pointing out that there must be a specific preparation for the cementation of these fibre posts within the root canal; the preparation of a canal that creates anchorage is recommended, the total length of the remnant being 2/3, with it being necessary to leave 4 mm of restorative material at the apex of the tooth, in addition to an adequate surface treatment and the use of conventional resin cement to provide better adhesiveness (Amritha *et al.*, 2023; Meimandinezhad *et al.*, 2023; Wag *et al.*, 2024).

The choice of theme: use of glass fibre and quartz fibre posts in the rehabilitation of endodontically treated posterior teeth, is justified by its current relevance, since fibre posts are widely used in the dental market and treatment alternatives are necessary for the development of dentistry (Meimandinezhad *et al.*, 2023).

And the present work aims to compare the fracture resistance of both the glass fibre post and the quartz fibre post in endodontically treated posterior teeth.

2 METHODOLOGY

This research will be based on the descriptive study of the integrative literature review type. Hassunuma *et al.* (2024) defines integrative review as “a powerful research tool. Its methodology allows a broad review of the literature and the creation of new knowledge from the reflection of the researcher based on the collection, extraction and analysis of pre-existing data.”

The present integrative review will allow the detailed and comparative analysis of the use of different fibre posts, namely glass fibre and quartz fibre, with a focus on the assessment of fracture resistance in rehabilitated posterior teeth, so that this study will be conceived and outlined following the stages expressed in the study by Souza, Silva and Carvalho (2010), who recommend the structure of the integrative review in the following six stages:

Initially, the 1st stage for preparing the integrative review will be carried out, whose purpose is the elaboration of the guiding question that will be used as the central point of the research, which must be answered at the end of the study.

Subsequently, the 2nd stage of the methodology, called search or sampling in the literature, will be carried out, whose purpose is the search for data on the basic theme of the main subject, providing a broad and diversified search. From this perspective, it is necessary to seek reliable information in the various digital scientific libraries, through the choice of criteria that correctly ensure the inclusion and exclusion of the articles found, in addition to the direct link between the use of the article and its correlation with the guiding question.

Soon after, the 3rd stage of the integrative review will be executed, defined as data collection, in which the researcher will select the data from the articles. It is essential to develop methods that ensure the extraction of the relevant data, guaranteeing precision and mitigating the risk of bias in the research, taking into consideration the inclusion of the definition of the subjects, methodology, sample size, variables and underlying concepts employed.

Next, the 4th stage of the work will be developed, in which the critical analysis of the included studies will occur, weighing the rigour and the characteristics of each study, using a classification of evidence; to define a hierarchy for these highlighted forms of evidence, an outline of the study is proposed, through levelling, that is, the study is divided into strata. In this interim, the first level of scientific evidence is located at the top of the pyramid, which presents systematic review studies and meta-analysis of multiple controlled and randomised clinical studies. Moving towards the base of the pyramid, the second level demonstrates the evidence obtained in individual studies with an experimental design. The third level demonstrates the evidence from quasi-experimental studies. The fourth level demonstrates the evidence from descriptive (non-experimental) studies or those with a qualitative approach. The fifth level demonstrates the evidence from case or experience reports and the sixth level demonstrates the evidence based on expert opinions.

Subsequently, the 5th stage of the descriptive study will be carried out, in which the presentation and discussion of the results will occur, with comparison of the data evidenced in the analysis of the articles, in addition to demonstrating the gaps found and the future perspectives for new studies.

Finally, the 6th stage will be carried out, whose objective is the presentation of the integrative review; in this final stage, all the information of the study is presented to the reader in a clear and complete manner, who will have a critical evaluation of all the exposed ideas.

The author of the work cannot omit evidence related to the theme and must be detailed in all their findings/results.

Following the sequences of the previous stages, from the first stage to the sixth stage, the guiding question that will be used in this integrative review is “Does the use of different types of fibre post present differences regarding fracture resistance in posterior teeth?”

From this perspective, the initial hypothesis (H1) infers that different types of fibre posts have differences regarding fracture resistance in posterior teeth. The second hypothesis (H2): the glass fibre post has greater fracture resistance when compared to the quartz post in posterior teeth. The null hypothesis (H3): the quartz fibre post has greater fracture resistance when compared with the glass fibre post in posterior teeth. The null hypothesis (H0): there are no significant differences between glass fibre and quartz posts regarding fracture resistance in posterior teeth.

Regarding the research procedure, a search was carried out in electronic platforms and databases; through descriptors taken from the Mesh (Medical Subject Headings), the keywords used were chosen, namely fiber quartz (quartz fibre), fiber glass (glass fibre) and dentistry, which were interlinked with the aid of the Boolean operator “and” and searched on the Scielo platform and the PubMed, Science Direct and Scopus databases.

For the delimitation of the research, exclusion and inclusion criteria for articles were chosen for a better selection of the studies that will compose this review. Regarding the exclusion criteria: articles that did not analyse fracture resistance in posterior teeth were excluded; articles that did not make the comparison between glass fibre and quartz fibre posts, duplicate articles and those not directly linked to dentistry; master's and doctoral theses and opinion articles were also disregarded.

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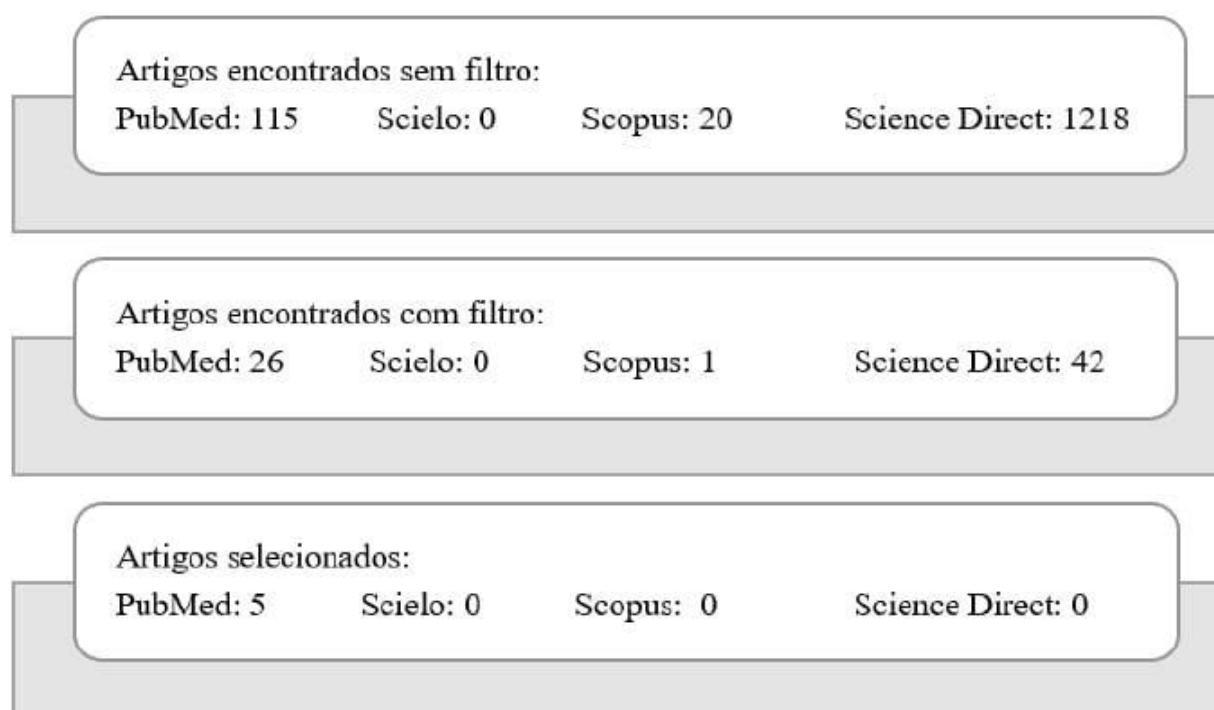
As for the inclusion criterion, articles that dealt, simultaneously, with glass fibre and quartz fibre posts, and with fracture resistance in posterior teeth were included; articles in which the abstract and the title were related to the theme discussed; articles that made the comparison between the different fibre posts; articles that were contained within the desired period, only the articles of the last 10 years being considered, from 2016-2026; and articles in the Portuguese and English languages.

To carry out the selection of articles, initially a reading of the title and abstract of each article was performed; soon after, the full reading of each work was carried out to define whether the articles really fit the main aspects of this research, highlighting the use of different fibre posts, both the glass fibre and the quartz fibre in posterior teeth, and that contain information on fracture resistance.

Thus, 1,353 records were found; after the filters, 63 publications were analysed, and only 5 articles were selected for meeting the requirements of the research in question. The entire course of the research and selection of the articles can be visualised in figure 1 below.

Figure 1

Flowchart of the data found in the research



Source: prepared by the authors, 2026.

Presentation and Analysis of Data

Table 1

Presentation and analysis of the selected studies

Author/Title/Year	Objective	Methodology	Result	Conclusion
KEÇEÇI, A. D. <i>et al.</i> Fracture resistance and failure mode of endodontically treated teeth restored using ceramic onlays with	It is to compare the fracture resistance and fracture modes of ceramic onlay restorations with or without fibre posts in	For this study, fifty extracted human premolars with similar anatomical characteristics were selected and used. Four groups (n =	No significant differences were found in the groups with fibre posts in terms of fracture resistance ($P > 0.05$). The negative	Within the limitations of this ex-vivo study, partial coverage with ceramic onlays resulted in a significant

or without fibre posts — an ex vivo study. 2016	endodontically treated premolars.	10) were endodontically treated. Onlay cavities extended to the buccal and palatal cusps and reaching the endodontic accesses were prepared. Ceramic onlay restorations with or without fibre posts were categorised as Group CO (ceramic onlays without posts), Group COQF (ceramic onlays and quartz fibre posts) and Group COGF (ceramic onlays and glass fibre posts). The positive control group was left unrestored (Group NR). Ten intact teeth were stored as the negative control group (Group IT). Fracture resistance was measured using a universal load-testing machine applying compressive load at a crosshead speed of 1 mm min ⁻¹ until fracture. Fracture resistance and modes were assessed statistically.	control group (IT) presented significantly higher fracture resistance than all the others ($P < 0.05$). The fracture types presented significant differences between the groups ($P < 0.01$).	improvement in the fracture resistance of endodontically treated premolars. However, the insertion of glass or quartz fibres did not significantly increase fracture resistance.
BATRA, R. <i>et al.</i> Fracture resistance in teeth treated using known endodontic techniques in Indian patients. 2022	We compared the efficacy of the zirconia post, glass fibre post, polyethylene fibre posts and quartz post.	For this study, forty-eight recently extracted mandibular first premolars were selected and randomly grouped into 4 different groups with 12 samples in each group. After endodontic treatment, the samples in all groups were submitted to post preparation, followed by	The data show that the zirconia post had the highest fracture resistance compared to other tested groups. In an inter-group analysis, excluding the zirconia post.	They assessed the fracture resistance of the glass fibre post with carbon and quartz posts and concluded that the quartz post had higher fracture resistance compared to other groups.

		restoration with the respective posts.		
MEIMANDI-NEZHAD, M. <i>et al.</i> Comparison of different surface treatment methods on flexural strength and elasticity modules of quartz and glass fibre-based posts: a narrative review. 2023	To assess the effect of different surface treatment methods on the FS and EM of quartz and glass fibre posts in the form of a narrative review study.	To conduct this study, all studies related to the subject under discussion during the years 2022-2000 were verified by systematic search in internationally available databases, including Web of Science, Science Direct, Scopus, PubMed and Google Scholar. Finally, completely relevant studies were selected to investigate the main objective.	Based on the results of some previous studies, the surface preparation of glass and quartz fibre posts by laser and 10% hydrogen peroxide has no effect on their FS and elasticity, with fracture resistance being little evidenced.	The results of previous studies are very contradictory and, therefore, it is not possible to provide a completely superior surface treatment method to increase flexural strength. The amount of flexural strength depends mainly on the intrinsic properties of the fibre post.
AMRITHA, K. M. Comparison of the fracture resistance of endodontically treated teeth restored with different aesthetic post and core systems in all-ceramic restorations cemented with two types of cements. 2023	The objective of this study is to assess the fracture resistance of three different post systems cemented by two varieties of luting cements, followed by core and full-coverage ceramic restoration. In this study, endodontic posts manufactured from zirconia, glass fibre and quartz are used.	For this study, thirty single-rooted endodontically treated mandibular premolars were selected, in which the post spaces were prepared and divided into three different groups. Group 1 (n = 10): zirconia post group. Group 2 (n = 10): quartz fibre post group. Group 3 (n = 10): glass fibre post group. Each group is subdivided into two based on the cementation system: resin-modified glass ionomer cement (RMGIC) or dual-cure resin cement (DCRC). The fracture resistance test was performed in a universal testing machine with a crosshead speed of 0.5 mm/min.	Within the zirconia post group, the mean fracture resistance was higher in the DCRC subgroup compared to the RMGIC subgroup and the difference was statistically significant ($p = 0.017$). The difference in fracture resistance between three different post systems was not considered statistically significant in relation to both cementation systems.	It was observed that when the zirconia post is used, the mean fracture resistance was higher in the dual-cure resin group compared to the resin-modified GIC group.
WANG, J. <i>et al.</i> Surface modifications of short quartz fibres and their influence on the	The objective of this study is to modify the surface properties of the fibre to improve the interfacial	In this study, we systematically introduced four different surface modification strategies on short	Of all the fillers, the SQFs-POSS demonstrated the best reinforcement effect, providing significantly greater	This work provided valuable insights into the optimisation of the filler-matrix interaction through modifications on the

physicochemical properties and in vitro cell viability of dental composites. 2024	interactions with polymeric resins.	quartz fibres (SQFs) for the preparation of dental composites. Particularly, acid etching was an easy way to create mechanical interlocking structures. In addition, the silanisation process, sol-gel treatment and polymer grafting were proposed to increase the surface roughness and the reactive sites. The effect of the surface modifications on the morphological changes of the fibre surface, mechanical properties, water stability and in vitro cell viability of dental composites were investigated.	improvements of 55.7%, 114.3% and 164.7% for flexural strength, flexural modulus and rupture energy, respectively, compared to the composites filled with SQFs.	fibre surface. Compared with glass fibres [17], [33], quartz fibres (QFs) are considered better reinforcements in dental composites owing to their higher compositional purity [34] and superior mechanical resistance.
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Source: prepared by the authors, 2026.

3 RESULTS AND DISCUSSIONS

Dental fibre posts are indispensable materials when it comes to the rehabilitative aspect; they provide both aesthetic value and resistance for endodontically treated posterior teeth. During the period of refinement of dentistry, fibre posts became predominantly more used than metallic posts, with their hybrid properties being greatly emphasised, relating mechanical and aesthetic-functional aspects (Batra *et al.*, 2022).

Currently, there is the availability of posts with different materials that have improved characteristics, with the glass fibre post standing out, which has high mechanical resistance, an elasticity modulus close to that of dentine, better adhesiveness and homogeneity with the resin; and the quartz fibre post also stands out, which has high mechanical resistance, in addition to an elasticity modulus similar to that of dentine, as well as better light transmission. It is worth emphasising that the surface treatment and the adequate preparation of the post are stages that interfere with the deflection capacity of these posts (Meimandinezhad *et al.*, 2023).

Fibre posts are better than metallic posts because they have peculiar characteristics; however, failures related to fracture can occur regardless of the type of post, with success in rehabilitative treatment being an association between several factors. The aspects of

occlusion, dental preparation, restoration and silanisation gain prominence (Keçec; Heidemann; Kurnaz, 2016; Meimandinezhad *et al.*, 2023).

Quartz fibre posts present themselves as slightly superior to the glass fibre post, observed through the elasticity coefficient being slightly closer to that of dentine. Furthermore, other factors such as: better adhesiveness after surface treatment and satisfactory chemical compatibility benefit the use of quartz fibre posts. However, these peculiarities of quartz fibre posts differ minimally from glass fibre posts (Amritha *et al.*, 2023; Meimandinezhad *et al.* 2023; Wag *et al.*, 2024). It is important to highlight that glass fibre posts, when used in the rehabilitative process, ensure results similar to those of quartz fibre posts, with their use being an efficient alternative with an economic advantage owing to the cost-benefit (Meimandinezhad *et al.*, 2023).

The mechanical characteristics of glass fibre and quartz fibre posts are undeniable; both dental materials have similar fracture resistances, but, in a secondary manner, the preparation of the clinical crown for the positioning of the post is an action that cannot be neglected. Posts that obtained partial coverage with ceramic onlays achieved a significant improvement in fracture resistance, showing that the preparation of the tooth and the material that will be used provided optimisation in the results (Keçec; Heidemann; Kurnaz, 2016).

It is recommended that the choice of conventional resin cement ensures multiple benefits regarding stress distribution, since correct cementation needs to create a better bond to the cervical, middle and apical thirds of the radicular dentine, allowing greater final resistance. The statistical analysis performed by the unpaired t-test and one-way ANOVA, All data were analysed with a significance level of $P < 0.05$, ensured that quartz fibre posts cemented with conventional resin cement provided a slight increase in fracture resistance (Amritha *et al.*, 2023). However, the cementation must be free of defects, with it being necessary to remove bubbles and correctly fill the post (Amritha *et al.*, 2023). Another important point is the aspect of the adhesiveness of the cement, which is only effective when there is a correct balance in the final restorative assembly, that is, effective adhesion must occur between post, core and reinforcement structure. Thus, efficient adhesion between post and cement increases longevity, reducing the risk of dental fracture (Batra *et al.*, 2022; Amritha *et al.*, 2023).

From this perspective, the analysis of the fibres that compose the post is important, by the fact that the alteration in their length can cause modifications in the biomechanical and biocompatibility properties. Short fibres (small length) of quartz can improve the aforementioned properties when the work is associated with composite resin. The amount of fibre that composes the post is also relevant; the greater the volume of fibre within the post,

the higher the resistance tends to be, increasing proportionally. However, a factor that must be taken into consideration is the excess of rigidity, with a balance between the amount of fibre and the degree of rigidity being necessary so that the reverse effect does not occur and the post does not fracture easily (Meimandinezhad *et al.*, 2023; Wag *et al.*; 2024).

The advantages of quartz fibre posts that differentiate them regarding translucency are not merely aesthetic, but are also related to the polymerisation potential, since the translucency will provide greater depth of polymerisation of the cement, which will reduce possible failures and bubbles, these caused mainly by the inadequate mixing of the cement and the combined application of cement and incorrect insertion of the post. In view of this, it will lead to a better cohesion of the restorations, distributing the loads in a balanced manner and reducing probable fractures (Amritha *et al.*, 2023). As for aesthetics, they are similar between quartz fibre posts and glass fibre posts, with this advantage being allowed because of the translucency of the posts, which facilitates the passage of light, obtaining better compatibility with the conventional resin cements used. Thus, for patients who have wide smiles, showing even the posterior teeth, the use of fibre posts is indispensable (Batra *et al.*, 2022; Amritha *et al.*, 2023).

Added to this, it is important to highlight that after a tooth suffers a fracture, the rehabilitative process must be adequately planned. Endodontically treated teeth without the subsequent use of a post have fractures that are normally irreparable. Teeth that suffered fractures, but had the presence of a post within the root, both the quartz fibre post and the glass fibre post, promoted more favourable coronal fractures, with a tendency to fracture above the gingival line, which ensures a better prognosis. The present work showed no difference between glass fibre and quartz fibre posts regarding the degree of fracture analysed (Keçec; Heidemann; Kurnaz, 2016).

Glass fibre posts are widely used in the rehabilitative process, being more famous than quartz fibre posts. In general terms, the main factors that foster the use of glass fibre posts are the acceptable clinical performance already proven, the better cost-benefit, in addition to the diversities of size in the market (Batra *et al.*, 2022).

In general lines, glass fibre posts can be better than quartz fibre posts when a careful surface treatment with sandblasting and silanisation is involved. Thus, this action can increase the retention properties of the posts and promote durability (Meimandinezhad *et al.*, 2023).

4 CONCLUSION

In view of the foregoing, both the glass fibre post and the quartz fibre post present excellent biomechanical properties and biocompatibility. However, a slight advantage of the quartz fibre post over the glass fibre post is notable, a fact proven by the elasticity modulus being slightly closer to that of dentine and by responding positively to surface treatments. However, in view of a general analysis, both fibre posts obtained success in the rehabilitative treatment of posterior teeth, with both the glass fibre post and the quartz fibre post being usable. It is worth emphasising that there are no significant differences between glass fibre and quartz posts regarding fracture resistance in endodontically treated posterior teeth. And also that the surface treatment and the use of conventional resin cement, in relation to self-adhesive resin cement, are factors that need to be taken into consideration to obtain success during oral rehabilitation.

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ABSTRACT

This article provides a comprehensive analysis of the historical, sociocultural, economic, and political impact of the Protestant Reformation in the Netherlands, emphasizing the role of Calvinism as a transformative force. The research traces the journey from the origins of the Reformed movement in the sixteenth century — through its precursors in the *Devotio Moderna* and the influences of Jan Łaski, Guido de Brès, and William of Orange — to the theological consolidation at the Synod of Dort (1618–1619) and the social, educational, and economic developments that defined the Dutch Golden Age of the seventeenth century. The study examines how the principle of *Sola Scriptura* drove a revolution in literacy, how the *Statenvertaling* (1637) standardised the language and access to knowledge, and how the Protestant work ethic shaped the capitalist spirit that enabled the rise of the Dutch East India Company (VOC) and the Amsterdam Exchange Bank. The analysis extends to the republican political structuring of the United Provinces, Abraham Kuyper's doctrine of Sphere Sovereignty, and the profound secularisation characterising the contemporary Netherlands. It concludes that the Reformation was not merely a religious event, but a first-order civilisational engine.

Keywords: Protestant Reformation. Calvinism. Netherlands. Golden Age. Literacy. Protestant Ethic. Synod of Dort. Dutch Society. Secularisation.

RESUMO

Este artigo analisa de forma abrangente o impacto histórico, sociocultural, econômico e político da Reforma Protestante nos Países Baixos, com ênfase no papel do calvinismo como força transformadora. A pesquisa traça o percurso desde as origens do movimento reformado no século XVI — com seus precursores na *Devotio Moderna* e as influências de Jan Łaski, Guido de Brès e Guilherme de Orange — até a consolidação teológica pelo Sínodo de Dort (1618–1619) e os desdobramentos sociais, educacionais e econômicos que definiram a Era de Ouro Holandesa no século XVII. O estudo examina como o princípio da *Sola Scriptura* impulsionou uma revolução na alfabetização, como a *Statenvertaling* (1637) padronizou a língua e o acesso ao conhecimento, e como a ética protestante do trabalho moldou o espírito capitalista que possibilitou a ascensão da Companhia das Índias Orientais (VOC) e do Banco de Amsterdã. A análise se estende à estruturação política republicana das Províncias Unidas,

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à doutrina da Soberania das Esferas de Abraham Kuyper, e à profunda secularização que caracteriza a Holanda contemporânea. Conclui-se que a Reforma não foi apenas um evento religioso, mas um motor civilizacional de primeira ordem.

Palavras-chave: Reforma Protestante. Calvinismo. Países Baixos. Era de Ouro. Alfabetização. Ética Protestante. Sínodo de Dort. Sociedade Holandesa. Secularização.

RESUMEN

Este artículo analiza de forma exhaustiva el impacto histórico, sociocultural, económico y político de la Reforma Protestante en los Países Bajos, con énfasis en el papel del calvinismo como fuerza transformadora. La investigación traza el recorrido desde los orígenes del movimiento reformado en el siglo XVI — con sus precursores en la Devotio Moderna y las influencias de Jan Łaski, Guido de Brès y Guillermo de Orange — hasta la consolidación teológica por el Sínodo de Dort (1618–1619) y los desarrollos sociales, educativos y económicos que definieron la Edad de Oro Holandesa en el siglo XVII. El estudio examina cómo el principio de la Sola Scriptura impulsó una revolución en la alfabetización, cómo la Statenvertaling (1637) estandarizó la lengua y el acceso al conocimiento, y cómo la ética protestante del trabajo moldeó el espíritu capitalista que posibilitó el ascenso de la Compañía de las Indias Orientales (VOC) y del Banco de Ámsterdam. El análisis se extiende a la estructuración política republicana de las Provincias Unidas, a la doctrina de la Soberanía de las Esferas de Abraham Kuyper, y a la profunda secularización que caracteriza a la Holanda contemporánea. Se concluye que la Reforma no fue solo un evento religioso, sino un motor civilizatorio de primer orden.

Palabras clave: Reforma Protestante. Calvinismo. Países Bajos. Edad de Oro. Alfabetización. Ética Protestante. Sínodo de Dort. Sociedad Holandesa. Secularización.

1 INTRODUCTION

The history of the Netherlands in the period between the sixteenth and seventeenth centuries represents one of the most fascinating and widely studied cases of civilisational transformation driven by religious ideas. Within a span of approximately one century, a peripheral region of the Habsburg Empire — composed of seventeen politically fragmented, economically diverse, and religiously heterogeneous provinces — emerged as the most prosperous, intellectually advanced, and politically innovative nation in Europe. This phenomenon, known as the Dutch Golden Age (*Gouden Eeuw*), was not the result of geopolitical accidents or simple geographical advantages. Its genesis is deeply rooted in a religious transformation of revolutionary proportions: the adoption of Calvinism as the cultural, ethical, and political matrix of the Dutch nation.

The Protestant Reformation, formally initiated by Martin Luther in 1517 with the publication of his Ninety-Five Theses, unleashed a process of reconfiguration of European societies that greatly transcended the ecclesiastical sphere. In the Netherlands, this process took on peculiar characteristics, shaped by the local context of resistance to Spanish absolutism, by the humanist tradition of the Netherlands, and by the presence of heterodox religious movements that had already prepared the ground for a critical reception of papal authority. The result was a unique synthesis of Reformed faith, civic engagement, and entrepreneurial spirit that bequeathed to the world some of its most enduring institutions: the stock exchange, the central bank, modern capitalism, and the principles of religious tolerance and representative government.

The relevance of this study extends beyond purely historical interest. Understanding how a theological transformation was able to eradicate mass illiteracy, structure a republican and democratic political system, and create the conditions for the economic and cultural flourishing of an entire nation offers invaluable lessons for contemporary debates on the role of religion in the public sphere, on the cultural foundations of economic development, and on the institutional conditions necessary for the creation of open and prosperous societies. Max Weber, in his seminal analysis, identified in the Protestant ethic one of the engines of modern capitalism. However, as we shall argue in this article, the Dutch legacy of the Reformation goes far beyond the economic sphere, encompassing educational, political, social, and cultural dimensions of equal or greater importance.

The present article is structured into ten main sections. Following this introduction, the arrival of the Reformation in the Netherlands in the sixteenth century is examined, identifying the principal historical agents and currents of thought that prepared the ground for the religious revolution. The third section analyses the process of consolidation of the movement,

with emphasis on the Eighty Years' War and the Synod of Dort. The fourth section is devoted to the impact on literacy and education. The fifth examines economic development, with particular attention to the Golden Age and the Weberian thesis. The sixth section deals with the political and social structuring of the Republic of the United Provinces. The seventh analyses the trajectory of Dutch Protestantism up to the present day, including the phenomenon of secularisation. Sections eight, nine, and ten present, respectively, the literature review, the benefits of the research, and the conclusion, followed by the references in the Vancouver format.

In methodological terms, this article situates itself within the tradition of the history of ideas and the historical sociology of religion, articulating primary sources (confessions of faith, synodal records, state documents) with the secondary academic literature of recent decades. The analysis seeks to overcome both the reductionism that minimises the role of religion in social development and the apologetic interpretations that attribute to the Reformation a mechanical and linear causality. The aim is a nuanced, critical, and comprehensive reading of one of the most significant chapters of modern history.

2 THE INTRODUCTION OF THE PROTESTANT REFORMATION IN THE NETHERLANDS (SIXTEENTH CENTURY)

2.1 PRECURSORS AND HISTORICAL GROUND

To understand the extraordinary receptivity of the Netherlands to Reformed ideas, it is essential to look back beyond the sixteenth century and identify the movements of spiritual renewal that had previously cultivated a mentality inclined to question established ecclesiastical authority. The most influential of these precursors was the *Devotio Moderna*, a movement of practical spirituality that emerged in the fourteenth century in the region of Guelders (present-day eastern Netherlands), founded by Geert Groote (1340–1384). This movement, which organised itself institutionally through the Brethren of the Common Life and the monasteries of the Congregation of Windesheim, promoted a personal and interior piety, centred on the imitation of Christ (*Imitatio Christi*) and the meditative study of the Scriptures.

The importance of the *Devotio Moderna* for the later Reformation lies in several respects. Firstly, it cultivated a habit of independent devotional reading which, once the Scriptures became more accessible following the invention of printing by Gutenberg (c. 1440), would evolve naturally into a personal reading of the Bible. Secondly, it developed an implicit critique of the formalism and corruption of the regular clergy, without, however, reaching an open rupture with Rome. Thomas à Kempis (1380–1471), whose *De Imitatione Christi* would become one of the most widely read books of Christendom, was formed in this tradition.

Thirdly, the Brethren of the Common Life administered high-quality schools, forming a generation of literate individuals that included figures such as the humanist Erasmus of Rotterdam, whose work of translation and textual criticism of the Bible directly prepared the intellectual ground for the Reformation.

Erasmus (1466–1536), although he never abandoned Catholicism and opposed Luther's positions on free will, exerted a paradoxical and decisive influence in preparing the Netherlands for the Reformation. His critical edition of the New Testament in Greek (1516), with a new Latin translation, demonstrated that the Church's official Vulgate contained significant translation errors, undermining the textual authority on which Rome based its doctrines. His satirical critique of clerical hypocrisy in works such as *The Praise of Folly* (1509) created a climate of scepticism towards ecclesiastical institutions that would be exploited by the reformers. It was no accident that the contemporary saying held that "Erasmus laid the egg that Luther hatched".

The political context also favoured the dissemination of Reformed ideas. The Netherlands was under the dominion of the Spanish Habsburgs, but maintained a tradition of local autonomy and urban governance that resisted the centralisation imposed by Charles V and, later, by Philip II. The mercantile cities of the northern provinces — Utrecht, Amsterdam, Leiden, Haarlem — possessed a literate and cosmopolitan bourgeoisie that received Reformed ideas from Germany, France, and Switzerland through established commercial routes. This urban bourgeoisie would find in Calvinism not only a theology, but an ideological justification for its aspirations towards political autonomy and economic freedom.

2.2 PRINCIPAL REFORMERS AND PROPAGATORS OF THE MOVEMENT

The introduction of Reformed ideas into the Netherlands was not the work of a single individual or event, but of a constellation of figures and movements which, in different waves and theological strands, gradually transformed the religious landscape of the region. Identifying these historical agents is fundamental to understanding the complexity and richness of the Dutch reforming process.

The **first wave** arrived with Lutheranism, in the years immediately following 1517. Luther's theses were rapidly printed and distributed in the cities of the Netherlands through the flourishing local printing industry. The linguistic and commercial proximity to Germany facilitated the circulation of these texts. However, Lutheran penetration encountered structural limitations: Lutheran ecclesiology, with its emphasis on the authority of princes over the territorial church (*cuius regio, eius religio*), was ill-suited to a region without a Protestant

sovereign, where political power remained in the hands of Charles V, an uncompromising defender of Catholic unity.

Hinne Rode deserves special mention as one of the first channels for Reformed theology of Zwinglian orientation. Rector of the school of the Brethren of the Common Life in Utrecht, Rode travelled to Zurich in 1523, where he maintained direct contact with Ulrich Zwingli. This meeting was especially significant with regard to the doctrine of the Lord's Supper: Rode presented to Zwingli the symbolic interpretation of the Eucharist (the “hoc est” meaning “hoc significat”), which would become a central point of distinction between the Zwinglian/Reformed and the Lutheran Reformation. Rode brought back to the Netherlands a sacramental understanding that would profoundly shape Dutch Reformed spirituality.

The **second wave**, and the more disturbing one, was **Anabaptism**. **Melchior Hoffman** (c. 1495–1543), a German furrier who embraced Anabaptism after passing through Lutheranism and Zwinglianism, became a charismatic and influential preacher in the Netherlands from 1530. With his apocalyptic message — prophesying that Strasbourg would be the “new Jerusalem” and that the second coming of Christ was imminent — Hoffman attracted thousands of followers in the northern provinces, especially among the urban lower classes displaced by economic transformation. Hoffmanite Anabaptism, with its rejection of infant baptism and of the hierarchical structures of society, represented a threat not only to the Catholic Church, but to the very established social order.

The violence of the Münster episode of 1534–35, when radical Anabaptists established a “theocratic kingdom” that was brutally suppressed, tarnished the Anabaptist cause and unleashed relentless persecution in the Netherlands. It was in this context that **Menno Simons** (1496–1561) emerged, a former Frisian priest who, in 1537, published his seminal treatise condemning the use of violence and reorganised the surviving Anabaptists around principles of non-violence, separation of church and state, and rigorous community discipline. His followers, the Mennonites, survived as a pacifist and economically prosperous minority, contributing enduringly to Dutch commercial and financial culture.

The **third and decisive wave** was **Calvinism**. The theology of John Calvin (1509–1564), systematised in his *Institutiones Christianae Religionis* (whose first edition dates from 1536), offered an intellectually rigorous and practically oriented synthesis that overcame the limitations both of Lutheranism and of Anabaptist radicalism. Calvinism reached the Netherlands mainly through two channels: the infiltration of texts and ideas coming from Geneva and Huguenot France, and the organisation of communities of Protestant refugees in German and English centres.

Jan Łaski (John a Lasco, 1499–1560), a Polish nobleman of Erasmian formation who had abandoned Catholicism for Reformed Protestantism, played a fundamental institutional role. As superintendent of the Strangers' Church in London (1550–1553), he developed a model of Presbyterian ecclesiastical organisation that would directly influence the Dutch Reformed churches. Forced to leave England after the accession of the Catholic Mary I, Łaski wandered through Europe, eventually returning to Poland, but leaving an organisational legacy that his disciples carried to the Netherlands. His emphasis on the Presbyterian structure — government by elected elders, synods for the resolution of theological disputes — became the model for the Dutch Reformed Church.

Guido de Brès (1522–1567) represents another crucial figure in the transmission and systematisation of Dutch Calvinism. Born in Mons (present-day Belgium), De Brès studied in Frankfurt and was a direct disciple of Calvin in Geneva. In 1561, while working clandestinely as a Reformed preacher in the southern Netherlands, he drafted the *Belgic Confession* (*Confessio Belgica*), a document of 37 articles that systematised Reformed doctrine for the context of the Netherlands. The Confession was deliberately composed as an apology addressed to King Philip II, seeking to demonstrate that the Protestants were not subversives or Anabaptists, but Christians who followed the Scriptures. De Brès was captured and executed in 1567, becoming a martyr of the Reformed cause, but his Confession survived as one of the foundational documents of Dutch religious identity.

2.3 THE FIRST PROTESTANT COMMUNITIES

The formation of the first Protestant communities in the Netherlands took place under conditions of severe clandestinity, forced by the Habsburg policy of repression. Charles V issued a series of increasingly severe edicts against heresy, culminating in the “Edict of Blood” of 1550, which made heresy a capital crime punishable by burning (men) or by the sword or live burial (women). It is estimated that between 1523 and 1566 approximately 1,300 people were executed for heresy in the Netherlands, many of them Anabaptists, but also a growing number of Reformed Calvinists.

In response to this persecution, the first Protestants developed creative forms of community organisation. The *hagenpreken* (hedge sermons) became a distinctive feature of Dutch Protestantism in the years 1550–60: Reformed preachers held open-air services, in fields and woods on the margins of the cities, attracting crowds that could disperse rapidly upon the arrival of the authorities. These events created a sense of community identity and solidarity that transcended divisions of social class, uniting wealthy merchants, artisans, and rural labourers around a shared faith and a common resistance.

The first formally organised Reformed churches in the Netherlands were established in the years 1540–1550, frequently with the help of pastors trained in Geneva or in other Reformed academies. Emden, a city in the northwest of Germany near the Dutch border, became a crucial refuge for Dutch Reformed exiles and a centre of pastoral training. In 1571, the first Synod of the Dutch Reformed Churches was held precisely in Emden, adopting a Presbyterian church order that would become the definitive model of the future Dutch Reformed Church.

3 CONSOLIDATION OF THE REFORMATION IN THE NETHERLANDS

3.1 KEY FIGURES IN THE CONSOLIDATION OF THE MOVEMENT

The consolidation of the Protestant Reformation in the Netherlands was a process that involved both religious leaders and political figures of exceptional historical stature. Understanding the specific contributions of these personalities is essential to grasping how Calvinism moved from a movement of a persecuted minority to a constitutive force of Dutch national identity.

William of Orange “the Silent” (1533–1584) occupies a singular place in this narrative on account of his personal trajectory and his role as the architect of the Dutch nation. Born a Catholic and raised at the court of Charles V, William was originally a loyal servant of the Habsburgs, a pragmatic statesman whose initial motivations were predominantly political. His gradual conversion to Protestantism — passing through Lutheranism and arriving at Calvinism — reflected not only a personal spiritual transformation, but also a political recognition that Calvinism was the most cohesive and committed social force in the resistance to Spain. William understood before other political leaders that the Dutch revolution needed a unifying element that transcended regional and class interests, and that the Reformed faith, with its emphasis on resistance to tyranny and on the sovereignty of God over all kingdoms, could provide this ideological cohesion.

The importance of William for the consolidation of the Reformation lies in two fundamental aspects. First, he conferred upon the Protestant cause an aristocratic and military legitimacy that allowed it to organise effective resistance against the Spanish army. Second, and more surprisingly for a sixteenth-century leader, he consistently advocated a degree of religious tolerance that was extraordinary for the time. The Pacification of Ghent (1576), which he negotiated, attempted to unite Catholic and Protestant provinces against Spanish domination. Although this attempt at a pan-religious Dutch alliance eventually failed, it revealed an ideal of pluralism which, ironically and paradoxically, would become a defining characteristic of Dutch culture.

Marnix de Sainte-Aldegonde (1540–1598), a direct disciple of Calvin in Geneva and a close friend of William of Orange, played a crucial role as theologian, diplomat, and man of letters of the Reformed cause. It was he who composed the *Wilhelmus*, the Dutch national anthem — one of the oldest in the world still in use — whose lyrics express a Reformed theology of dependence on God and resistance to tyranny. Marnix also drafted the Act of Abjuration of 1581, the document by which the United Provinces declared their independence from Philip II, a document that would later influence the American Declaration of Independence.

Franciscus Gomarus (1563–1641) and **Jacobus Arminius** (1560–1609) represent the two poles of the great internal theological debate that marked the maturity of the Dutch Reformation. Gomarus, a professor at Leiden, defended the strictest version of Calvinism, including the doctrine of double predestination (according to which God had predestined some to salvation and others to damnation from before the creation of the world). Arminius, also a professor at Leiden, questioned this doctrine, arguing that divine predestination was based on God's foreknowledge of human faith. This debate — apparently esoteric — had profound implications for questions of political sovereignty, human nature, and the structure of society, becoming the catalyst for the great council that would definitively seal the theological identity of Reformed Holland.

3.2 THE EIGHTY YEARS' WAR AND INDEPENDENCE

The Eighty Years' War (1568–1648), also known as the Dutch Revolt, was the crucible in which Dutch national identity and its particular form of Calvinism were forged. This long and costly conflict — which involved episodes of siege and surrender of cities, naval battles, European diplomacy, and military innovations — cannot be understood simply as a war of political independence. It was equally a religious war, a social revolution, and a philosophical dispute about the nature of legitimate authority.

The immediate spark of the conflict was the *Beeldenstorm* (Iconoclastic Fury) of August 1566 — an outbreak of iconoclasm that swept through the southern and northern Netherlands within a matter of weeks, resulting in the destruction of images, altars, and decorations in hundreds of Catholic churches. The *Beeldenstorm* was partly spontaneous and partly organised by Calvinist militants who saw in religious icons a concrete expression of the idolatry that the Reformation condemned. For Philip II, the episode was a declaration of war against his sovereign authority and his mission of defending the Catholic faith. His response was to send the Duke of Alba with an army of approximately 10,000 soldiers who were veterans of the Italian wars.

Fernando Álvarez de Toledo, Duke of Alba (1507–1582), arrived in the Netherlands in August 1567 and immediately established the “Council of Troubles” — nicknamed by the Dutch the “Council of Blood” — a tribunal that operated outside local laws and legal traditions and that condemned thousands of people to death or exile. Among those executed were the Count of Egmont and the Count of Horn, Catholic noblemen who had opposed the extremist policies of Madrid but who were not Protestants. This indiscriminate brutality proved politically counterproductive: by attacking even moderate Catholics, Alba alienated a large part of the nobility and bourgeoisie that might have remained loyal to Philip II.

The war that followed was marked by phases of advance and retreat. William of Orange financed mercenary armies with his own resources and launched several failed invasions from exile. The strategic turning point occurred in 1572, when the so-called “Sea Beggars” (*Watergeuzen*) — Protestant privateers operating from English and German ports — captured the port city of Brill (Den Briel), unleashing a wave of uprisings in the northern provinces that rapidly expelled the Spanish garrisons from numerous cities. From this moment on, the northern provinces — headed by the wealthy province of Holland — became the base of operations of the resistance, with William as their *Stadtholder*.

The Union of Utrecht (1579) formalised the alliance of the northern provinces: Holland, Zeeland, Utrecht, Guelders, Friesland, Overijssel, and Groningen. This document established a treaty of mutual defence and political coordination that would serve as the constitutional basis for the new republic. The Act of Abjuration of 1581 was the final step: drawing on a natural-law and Reformed logic concerning the limits of sovereign authority, the United Provinces formally declared that Philip II had forfeited his right to govern by violating the privileges and rights of his subjects, thereby becoming a tyrant. With this revolutionary act, the Republic of the Seven United Provinces of the Netherlands was born — the first modern republic in European history.

The war continued for a further six decades after the Abjuration, but the de facto independence of the United Provinces was established. The Treaty of Münster (1648), part of the Peace of Westphalia, formally recognised the sovereignty of the Dutch Republic before Spain and the Holy Roman Empire, bringing to an end 80 years of conflict. During this long period, the Reformed faith had consolidated itself as the public religion of the republic — the Dutch Reformed Church (*Nederduitse Gereformeerde Kerk*) was the only publicly recognised church, with its pastors paid by the state and its temples being the medieval churches confiscated from the Catholics. Although the republic did not officially prohibit Catholicism or other confessions, they were obliged to practise their faith in private, while the Reformed Church enjoyed an incontestable public privilege.

3.3 THE SYNOD OF DORT AND THEOLOGICAL CONSOLIDATION

If the Eighty Years' War represented the political and national consolidation of the Dutch Reformation, the Synod of Dort (Dordrecht, 1618–1619) was its theological equivalent. This international council — attended by delegates from Reformed churches in England, Scotland, France, Switzerland, Germany, and Nassau, in addition to all the Dutch provinces — was convened to resolve the theological crisis generated by the Arminian Controversy.

The immediate context was explosive. The followers of Arminius, known as Remonstrants, had published in 1610 the *Five Articles of Remonstrance*, questioning the Calvinist doctrines of unconditional predestination, limited atonement, and the perseverance of the saints. The debate had rapidly spilled over from the ecclesiastical sphere to become a matter of political life: the Grand Pensionary Johan van Oldenbarnevelt, the most powerful civil official of the republic, supported the Remonstrants, partly for theological reasons and partly out of political calculations aimed at increasing provincial authority over the church. The *Stadtholder* Maurice of Nassau, son of William of Orange, supported the orthodox Calvinist Gomarists. The conflict culminated in the arrest and execution of Oldenbarnevelt in 1619 — one of the darkest episodes in Dutch republican history — and in the exile of the theologian and jurist Hugo Grotius, who sympathised with the Remonstrants.

Presided over by Johannes Bogerman (1576–1637), the synod met from November 1618 to May 1619, over 180 sessions. After hearing and refuting the Remonstrant positions, the synod formulated the *Canons of Dort*, a doctrinal document that reaffirmed Calvinist orthodoxy in five chapters corresponding to the five Arminian Remonstrances: the total depravity of the human being, unconditional election on the part of God, the limited atonement of Christ (whose benefits are applied only to the elect), the irresistible grace of the Holy Spirit, and the perseverance of the saints. These five points would become known in the Anglo-Saxon world under the acronym TULIP.

In addition to the dogmatic decisions, the Synod of Dort took practical decisions of immense social impact. It ordered the translation of the Bible into Dutch from the original languages (which would result in the *Statenvertaling* of 1637), established guidelines for primary education in all parishes, regulated the catechism as a pedagogical instrument, and determined that pastors should give special attention to the instruction of children. The Synod was, therefore, much more than a theological council: it was a founding moment of a civilisation, in which the religious and intellectual elite of the Dutch republic outlined the educational, cultural, and spiritual project that would guide the nation for centuries.

The Canons of Dort (1619) — Summary: The document consolidated Dutch Reformed theology around five fundamental affirmations, frequently termed in the

Anglophone world as TULIP: (T) Total Depravity — human nature is entirely corrupted by sin; (U) Unconditional Election — God freely elects without regard to human merit; (L) Limited Atonement — Christ died specifically for the elect; (I) Irresistible Grace — the Holy Spirit effectively transforms the heart of the elect; (P) Perseverance of the Saints — the elect never definitively lose salvation. This theological system would shape the ethics, education, and public life of the Netherlands for more than two centuries.

4 IMPACT ON LITERACY AND EDUCATION

4.1 DEVELOPMENT OF POPULAR EDUCATION AND SCHOOLS

The impact of the Calvinist Reformation on Dutch education constitutes perhaps the most dramatic and empirically documented example of how a theological transformation can produce far-reaching social consequences. To understand this phenomenon, it is necessary to start from the theological principle that motivated it: *Sola Scriptura* — the doctrine that the Bible is the sole and supreme authority for the Christian faith and life. If the Scriptures are the direct word of God to the believer, then every believer has not only the right but the sacred duty to read them personally and as a family. This apparently simple theological conclusion had revolutionary consequences: it transformed literacy from a technical skill reserved for clergy, scribes, and merchants into a spiritual necessity of the first order for every member of the Christian community.

The complementary doctrine of the *priesthood of all believers* reinforced this logic. By affirming that there is no intermediary priestly caste between the believer and God, that every Christian is a priest before the Lord, Calvinism eliminated the figure of the priest as an irreplaceable and necessary mediator of access to the sacred. In practice, this meant that each head of household was responsible for the religious instruction of his children and dependants, which made the ability to read a domestic responsibility of a religious character.

The Synod of Dort (1618–1619) transformed these theological convictions into concrete ecclesiastical policy. Article 2 of the School Regulation adopted by the synod determined that in every city and every village a school should be established, funded by the State or the Church, where children were to be instructed to read, write, understand the catechism, and practise the fundamentals of the Reformed Christian religion. This was not an abstract educational programme, but an institutional mandate with mechanisms of implementation: the consistories (governing councils of the local churches) were responsible for supervising the schools, the pastors were to inspect the pupils' progress regularly, and the civil magistrates were compelled to fund the schools and to ensure that all children — including the poor — had access to instruction.

In practical terms, the resulting educational system was structured on multiple levels. The *Kleine Scholen* (Small or Elementary Schools) were established in the local parishes to provide basic instruction in reading, writing, arithmetic, and catechism. Above these were the *Latijnse Scholen* (Latin Schools), which prepared students for university with instruction in Latin, Greek, rhetoric, and philosophy. At the top of this hierarchy were the universities, of which that of Leiden was the most prominent. This integrated system, funded by a combination of ecclesiastical, municipal, and provincial resources, constituted the first outline of a system of public education in the history of modern Europe.

The role of teachers was also radically transformed. In the medieval tradition, teaching was primarily the responsibility of the clergy. In the Dutch republic, the schoolmasters (*schoolmeesters*) became a distinct professional category, frequently examined and approved by the ecclesiastical consistories to verify their doctrinal orthodoxy, but exercising an increasingly civil function. Many schoolmasters in the small communities also accumulated the functions of municipal secretary, examiner, and pre-deacon of the local church, becoming central figures in community life.

4.2 THE STATENVERTALING AND THE LINGUISTIC IMPACT

The publication of the *Statenvertaling* in 1637 represents one of the most significant moments not only in religious history, but in the cultural and linguistic history of the Netherlands. This translation of the Bible, commissioned by the Synod of Dort in 1618 and financed by the States General (the federal parliament of the republic), was the result of nearly two decades of meticulous work by a team of highly qualified scholars.

The translators were carefully chosen from among the greatest specialists in Hebrew and Greek in the republic: Johannes Bogerman and Gijsbert Voetius for the Old Testament, Festus Hommius and Jacobus Revius for the New Testament, among others. The methodology adopted was explicitly scientific by the standards of the time: the translation was to be made directly from the original texts in Hebrew and Greek, without the mediation of the Latin Vulgate, and was to reproduce the syntactic structure and idiomatic nuances of the originals as far as possible in Dutch, preserving the literary texture of the Scriptures.

The linguistic impact of the *Statenvertaling* was analogous to that which Luther's Bible exerted on German or the King James Bible on English: it became the literary and linguistic standard that shaped modern Dutch. In a country with significant dialectal variations between the provinces — the differences between the Dutch of Utrecht, that of Groningen, and that of Zeeland were considerable — the *Statenvertaling* provided a unified literary Dutch that transcended the regional dialects. Being read and heard in all the churches of the country, in

all families and in all schools, it established a linguistic standard that strengthened the common cultural identity of the united provinces far more than any political decree could have done.

From an educational point of view, the *Statenvertaling* functioned as the nation's principal textbook. At a time when printed materials were expensive and books relatively scarce, the presence of the Bible in almost every Dutch home — guaranteed by the subsidies of the state and the Church — ensured that every family that invested in the literacy of its children would have an immediate, rich, and highly literary reference text. Children learned to read by identifying words they already knew by heart from the oral instruction of the catechism and the Sunday services. The Bible was not merely a sacred book; it was the first book that most seventeenth-century Dutch people learned to read.

4.3 CREATION OF UNIVERSITIES AND CENTRES OF LEARNING

If the parochial primary schools represented the base of the educational pyramid built by the Reformation, the universities were its apex and its most eloquent expression of the Reformed vision of a community of faith fully committed to knowledge. The foundation of the **University of Leiden** in 1575 is a symbolic event of the first order. William of Orange granted it to the city as a reward for its heroic resistance during the Spanish siege of 1574–1575 — the inhabitants of Leiden withstood the siege for more than a year, suffering severe famine, before being relieved by the “Sea Beggars” who flooded the polders. The university was, therefore, both a prize for bravery and a deliberate investment in the intellectual future of the republic.

Leiden rapidly became one of the most important intellectual centres in Europe. Its location in the Netherlands — where the relative freedom of the press and intellectual tolerance were superior to those of any other European country — attracted scholars who elsewhere would have faced persecution. René Descartes lived in the Netherlands for 20 years (1628–1649), taking advantage of this atmosphere of freedom.

Baruch Spinoza, a Dutch Jewish philosopher, produced in Amsterdam works that would have been impossible anywhere else in Catholic Europe. Hugo Grotius, the founder of modern international law, developed at Leiden his ideas on natural law and the laws of war. This concentration of intellectual talent was not accidental: it was the direct result of a religious and state policy that valued knowledge as an essential dimension of the pious and republican life.

In addition to Leiden, other universities were founded during the Golden Age: the University of Franeker in Friesland (1585), the University of Groningen (1614), the University

of Utrecht (1636), and the University of Harderwijk (1648). This extraordinary number of universities — five institutions for a population of approximately 2 million people at the beginning of the seventeenth century — reflects both the commitment to higher education and the federal structure of the republic, where each major province wished to have its own institution for the training of pastors and magistrates.

4.4 COMPARATIVE LITERACY RATES

The results of the educational policies driven by the Reformation are empirically measurable and reveal an extraordinary divergence between Holland and the rest of Europe. Historical studies on literacy in the early modern period fundamentally use two types of evidence: the ability to sign one's own name on official documents (such as marriage registers, inventories, and contracts) and the number of works published and sold. Although the signature is only an approximate indicator of full literacy, it provides quantifiable data that allow robust historical comparisons.

Table 1*Estimated Literacy Rates in Western Europe (Seventeenth–Eighteenth Centuries)*

Country / Region	c. 1650 — Men (%)	c. 1650 — Women (%)	c. 1750 — Men (%)	c. 1750 — Women (%)
Dutch Republic (Holland)	75	50	85	64
England (London)	65	35	70	45
Scotland (cities)	60	30	65	40
France (North)	35	15	50	27
Spain (Castile)	20	8	30	12
Italy (Central)	22	10	32	14

Source: prepared by the authors.

Note: Estimated data based on Eskelson (2021), Stone (1969), and Graff (1987). The rates vary significantly between urban and rural areas within each country.

As the table above shows, the Dutch Republic had rates of male literacy that were double those of France and almost four times those of Spain in the mid-seventeenth century. Even more remarkable is the rate of female literacy: with 50% of adult women able to sign their name in the mid-seventeenth century, Holland was generations ahead of any other European country in this respect. This datum is especially significant because it reveals that the Dutch educational revolution was not limited to the male sex — although gender inequality persisted, it was dramatically smaller than in the neighbouring countries.

Eskelson (2021), in his study on institutions and literacy in early modern Western Europe, argues that the difference between Protestant and Catholic countries cannot be explained by the religious factor alone; variables such as urbanisation, per capita wealth, and the existence of commercial networks also play a significant role. However, he concludes that, controlling for these variables, the specific influence of Protestant institutions — especially Holland and Scotland — on literacy rates remains statistically significant, suggesting a genuine causal effect of Reformed Protestantism on popular education.

Another revealing indicator is the number of books published. In 1630, the Dutch Republic was responsible for approximately half of the entire typographical output of Europe.

Amsterdam had become the largest publishing centre in the world, publishing not only religious texts but also scientific, philosophical, literary, and political works that were censored in other European countries. This publishing flourishing was both a cause and a consequence of the high literacy rate: a literate population created demand for books, and the availability of books encouraged literacy.

5 ECONOMIC DEVELOPMENT

5.1 THE PROTESTANT ETHIC AND THE DUTCH CAPITALIST SPIRIT

The connection between Reformed Protestantism and economic development was analysed most influentially by the German sociologist Max Weber in his work *The Protestant Ethic and the Spirit of Capitalism* (1904–1905). The Weberian thesis, although widely debated, contested, and nuanced by subsequent research, remains an unavoidable point of departure for understanding the Dutch phenomenon. For Weber, Calvinism developed a set of attitudes and practices in relation to work, money, and material life that were especially conducive to the development of a rational and methodical capitalist economy.

The first element of this ethic was the doctrine of *vocation* (*Beruf* in German, *roeping* in Dutch). Whereas in the medieval Catholic tradition God's "calling" was primarily understood as a call to the contemplative religious life (monasticism), Calvinism radically democratised the concept: any legitimate activity — whether craftsmanship, commerce, agriculture, medicine, or the magistracy — was a divine calling that the believer was to exercise with the utmost diligence and excellence. This theological dignification of secular work had powerful behavioural consequences: to work with discipline, efficiency, and integrity was not merely an economic virtue, but an act of worship of God.

The second element was *inner-worldly asceticism*, the paradoxical combination of an intense activity in the world (and therefore of the production of wealth) with a rigorous restriction on personal consumption. The orthodox Calvinist was not a monk who fled from the world, but neither was he an aristocrat who displayed his wealth in feasts and palaces. He worked intensely, accumulated wealth, but consumed only what was necessary for a pious and ordered life. The mathematical result of this combination was inevitable: the difference between production and consumption, between income and expenditure, was systematically reinvested in the business itself or in the community, generating an accumulation of capital on an unprecedented scale.

The third element was the soteriological anxiety produced by the doctrine of predestination. If salvation was predetermined by God before the creation of the world, and if human beings could not, by their own works, influence this divine decision, how could the

believer have any certainty that he was one of the elect? Weber argued that Calvinists sought external signs of election in their successes in work and business: material prosperity, the product of a life of discipline and diligence, became a psychological evidence of divine grace. Although this relationship between prosperity and election was never affirmed as official doctrine by the Reformed churches, it functioned as a powerful psychological engine that drove the economic behaviour of believers.

It is important to note that the relationship between Calvinism and capitalism is not without historical complexity. Historians such as Amintore Fanfani (1935) and Hugh Trevor-Roper (1967) questioned different aspects of the Weberian thesis. Fanfani argued that commercial capitalism already existed in Catholic Italy of the fifteenth century, independently of Protestantism. Trevor-Roper observed that many of the most important entrepreneurs of the Dutch Golden Age were refugees from the southern Netherlands — Flemings and Brabanters — whose economic dynamism was not exclusively determined by religion, but also by their displacement from the Catholic centres and the need to rebuild their fortunes in a new environment.

However, these objections, though pertinent, do not refute the Dutch phenomenon as a whole. As the historian Jonathan Israel argues in his monumental *The Dutch Republic: Its Rise, Greatness, and Fall 1477–1806* (1995), what distinguished the Dutch economy was not merely the individual spirit of its entrepreneurs, but the institutional ensemble that Calvinism helped to create: an educational system that produced a highly literate and numerically competent workforce; an ethic of commercial trust based on the word of honour and on the community ties of church membership; a theological distrust of state absolutism that favoured the creation of a regulatory environment favourable to commerce; and a network of trans-regional and transnational solidarity among Reformed communities that facilitated credit and commercial information.

5.2 THE DUTCH GOLDEN AGE (SEVENTEENTH CENTURY)

The Dutch Golden Age (*Gouden Eeuw*), which spans approximately the seventeenth century, represents one of the most extraordinary periods of cultural, scientific, and economic flourishing in the history of humanity. A nation of approximately two million inhabitants — smaller than many contemporary European cities — controlled the largest maritime trade in the world, possessed the most sophisticated financial institutions on the planet, produced some of the greatest artists (Rembrandt, Vermeer, Hals) and scientists (Huygens, van Leeuwenhoek) of its time, and established colonies and trading posts on four continents.

The Dutch economic ascent was driven initially by what the Dutch themselves called the “mother trade” (*moedernegotie*): the grain and timber trade of the Baltic. Already in the fifteenth century, Dutch merchants dominated the routes between the producing ports of the eastern Baltic (Danzig, Riga, Königsberg) and the consumer markets of the Netherlands, France, and the Iberian Peninsula. This dominant position in the trade of essential commodities provided the initial capital and the commercial networks on which the future global expansion would be built. The *fluiten* — Dutch merchant ships of innovative design, more efficient and cheaper to operate than the English or Portuguese equivalents — gave the Dutch merchant fleet a decisive competitive advantage.

The expansion into the trade of Asian spices — pepper, nutmeg, clove, cinnamon — which the Portuguese had dominated since the beginning of the sixteenth century, represented the next step in the Dutch economic ascent. The creation of the *Vereenigde Oost-Indische Compagnie* (VOC) in 1602 was the organisational response to this challenge. With initial capital of 6.5 million guilders raised from more than 1,000 shareholders in six regional chambers, the VOC was not only the first joint-stock company in history, but also the first to possess quasi-sovereign powers: the right to wage war, to negotiate treaties, to mint coin, and to administer territories. Supported by a permanent fleet of warships and by the accumulated capital of its shareholders — many of whom were prominent members of the Reformed Church — the VOC expelled the Portuguese from their strategic positions in the Indian Ocean and established a commercial empire that extended from Batavia (present-day Jakarta) to Ceylon, from the Malabar Coast to Japan.

In parallel with global trade, the Dutch domestic economy diversified and modernised in an impressive manner. Specialised agriculture — especially tulip flowers, whose speculative fever of 1636–37 may be considered the first financial bubble in history — was highly productive. The dairy industry, the herring fishery in the North Sea (with technical innovations such as the curing of the fish on board the boats), the textile industry of Leiden and Haarlem, shipbuilding, and the production of Delft ceramics (inspired by the Chinese porcelain brought by the VOC) constituted a diversified industrial base. This integrated economy was sustained by a financial system of unparalleled sophistication: the Bank of Amsterdam (1609), the Amsterdam Loan Bank (1614), the Amsterdam Stock Exchange (1609), and a developed marine insurance market created a system of mobilisation and allocation of capital that would only be surpassed by the English Industrial Revolution of the eighteenth century.

5.3 COMMERCIAL EXPANSION, THE VOC, AND THE IMPACT ON CLASS STRUCTURE

The Dutch commercial expansion of the Golden Age had profound implications for the internal social structure of the republic. Unlike the European feudal monarchies, where wealth and power were fundamentally associated with the possession of land and aristocratic birth, the Dutch commercial economy created a ruling class of mercantile origin — the *regenten* (regents) — whose power was based on the commercial and financial capital accumulated through business.

This class of regents controlled not only the great commercial companies, but also the municipal and provincial administration. In the assemblies (Estates) of the provinces and in the municipal councils, it was the representatives of this wealthy bourgeoisie who made the political decisions. Their power was, to a certain degree, counterbalanced by the influence of the Reformed pastors and by the populism of the artisans and skilled workers organised in the craft guilds. This tension between different social groups, all articulating their demands through a representative political structure, brought the Dutch republic closer to a modern democracy than any other form of European government of the seventeenth century.

The Calvinist ethic of work and saving created, according to some historians, a culture of social mobility based on merit that was remarkably rare for the time. Although the republic was not an egalitarian society — the disparities of wealth were considerable, especially between the great merchants of the VOC and the workers of the shipyards — the dominant cultural narrative valued self-improvement through diligent work, education, and integrity, not the privilege of birth. This mentality favoured upward social mobility for those who demonstrated the Reformed virtues of discipline, frugality, and commercial honesty.

6 POLITICAL AND SOCIAL STRUCTURING

6.1 THE POLITICAL SYSTEM OF THE UNITED PROVINCES

The Republic of the Seven United Provinces constituted an unprecedented political experiment in seventeenth-century Europe. On a continent dominated by absolutist monarchies that asserted the divine right of kings, the Netherlands developed a republican, federalist, and representative system that challenged the dominant political logic of the time. Understanding how Calvinist theology contributed to the formation and legitimation of this political system is essential to evaluating the historical legacy of the Dutch Reformation.

The theological basis of Dutch republicanism lay, in part, in the Calvinist doctrine of *total depravity*. This doctrine, which holds that all dimensions of human nature — including reason and will — are corrupted by sin since the Fall of Adam, had profound political implications: if no human being is intrinsically good enough to exercise unlimited power over

his fellow human beings without succumbing to corruption and tyranny, then no political system should concentrate excessive power in a single person or institution. This theological distrust of absolute human power translated into a practical preference for systems of checks and balances, division of power, and institutional accountability.

The political system of the United Provinces reflected this philosophy in its structure. Sovereignty resided formally in the seven provinces (Holland, Zeeland, Utrecht, Guelders, Overijssel, Friesland, and Groningen), each with its own provincial assembly (the *Staten*). These assemblies, in turn, sent delegates to the *Staten-Generaal* (States General), the federal body in The Hague that coordinated foreign policy, defence, and other matters of common interest. Crucially, decisions in the States General on fundamental questions required unanimity among the provinces, ensuring that none of them — not even the far richer and more populous Holland — could impose its will on the others.

The executive power was divided between two potentially rival centres. The *Stadtholder* — an office that in practice remained in the House of Orange-Nassau during most of republican history — was the military commander and the arbiter of provincial disputes. The Grand Pensionary (*Raadspensionaris*), the highest civil official of the province of Holland, was the principal diplomatic negotiator and the spokesman for the commercial interests of the urban bourgeoisie. The tension between these two sources of authority created a fluid political dynamic which, although it sometimes generated crises (such as the one that culminated in the execution of Oldenbarnevelt in 1619 and the “murder” of Oldenbarnevelt's brother), prevented the crystallisation of power in a single centre.

This political system was intellectually justified through a legal and philosophical theory that combined classical natural law with Reformed principles. **Hugo Grotius** (1583–1645), the greatest jurist of the period, developed in works such as *De Jure Belli ac Pacis* (1625) a theory of international law and just war that was explicitly founded on principles of natural law, but which resonated with the Reformed ethic of responsibility and limitation of state power. The Act of Abjuration of 1581 itself, by justifying the deposition of Philip II on the basis of his violation of the fundamental rights of his subjects, anticipated arguments that would only be fully developed by John Locke at the end of the seventeenth century.

6.2 RELIGIOUS TOLERANCE AND PLURALISM

One of the most paradoxical and fascinating aspects of the Dutch republic was its practice of relative religious tolerance, which contrasted vividly with the wars of religion that devastated the rest of Europe during the same period. Although the Reformed Church was the only publicly privileged denomination — with its pastors paid by the state and its temples

being the public churches — the other religious confessions were, for the most part, tolerated in practice, provided they contented themselves with the private practice of their worship.

The Catholics, who constituted a significant minority especially in the southern provinces and the border regions, could practise their faith in “hidden churches” (*schuilkerken*) — residential spaces converted into places of worship that were of general knowledge to the authorities, but which were tacitly tolerated in exchange for the payment of fees. The Mennonites and other Anabaptist denominations, whose pacifism and industriousness made them economically valuable citizens, were generally tolerated, especially in Amsterdam. The Lutherans maintained their own congregations in the cities. The dissident Calvinists (Remonstrants) found refuge after the Synod of Dort especially in Amsterdam and in other cities.

Even more remarkable was the tolerance extended to the Jews. Amsterdam became at the beginning of the seventeenth century one of the principal centres of the European Jewish diaspora, receiving both Sephardic Jews expelled from the Iberian Peninsula (where they had suffered the persecutions of the Inquisition and been forced to convert to Catholicism as *conversos*) and Ashkenazi Jews from Central and Eastern Europe. The Jews could openly practise their religion, maintain synagogues and academies of religious study (*yeshivot*), and participate in the economic life of the republic to degrees of freedom without parallel in the contemporary Christian world. Baruch Spinoza (1632–1677), born in the Sephardic community of Amsterdam, although eventually excommunicated by his own community, produced his revolutionary philosophical works in an environment that, despite its tensions, was fundamentally more open than any other in Europe.

This practice of tolerance should not be romanticised or seen as a coherent application of the modern principle of religious freedom. It had fundamentally pragmatic bases: the republic needed to attract and retain human and financial capital, and religious persecution was economically destructive. The Jewish merchants, the Mennonite artisans, the Sephardic financiers, the Flemish artisans who were refugees from the wars of religion of the south — all contributed skills, capital, and commercial networks that the republic needed. In addition, many of the regents who governed the cities had a political interest in keeping the Calvinist pastors under control, preventing the Reformed Church from becoming a state within the state. Tolerance was, in part, an instrument of governance that kept clerical influence within acceptable limits.

However, regardless of its motivations, the effects of Dutch tolerance on the intellectual culture of the republic were immeasurable. The possibility of publishing works prohibited in other countries, the presence of communities of different religious and intellectual traditions,

and the lesser intervention of ecclesiastical censorship in public life created in Amsterdam and the other cities of the republic an environment of intellectual pluralism that was, for more than a century, the most fecund in Europe.

6.3 SPHERE SOVEREIGNTY: ABRAHAM KUYPER AND THE POLITICAL LEGACY OF CALVINISM

Abraham Kuyper (1837–1920) represents the most elaborate and influential synthesis of Dutch Calvinism as a political and social philosophy. Pastor, theologian, journalist, founder of a political party, founder of a university, professor, and Prime Minister of the Netherlands between 1901 and 1905, Kuyper was one of the most extraordinary figures of the nineteenth and early twentieth centuries, whose influence extended well beyond the Dutch borders.

Kuyper's most enduring contribution to political philosophy was the doctrine of *Sphere Sovereignty* (*Souvereiniteit in eigen kring*), elaborated in his celebrated inaugural lecture at the Free University of Amsterdam in 1880 and developed over the course of his career. The central thesis of this doctrine is that God created society as a plurality of spheres of authority — family, church, state, science, art, commerce, etc. — each with its own sovereignty derived directly from divine ordination, not from the delegation of the state. The role of the state, according to Kuyper, is threefold: to guarantee harmony among the spheres; to prevent any one of them from dominating or invading the others; and to protect individuals within each sphere against abuses of power.

This doctrine had radical implications for practical politics. In the first place, it provided a theological justification for institutional pluralism: in a confessional Christian society such as the Netherlands, different religious groups — Calvinists, Catholics, Lutherans — had the right to their own schools, universities, newspapers, and social organisations, each with its own confessional identity, without the state imposing a secularist uniformity or a dominant religious denomination upon all. In the second place, it structurally limited the power of the state: the government had no authority to intervene in the internal affairs of the family, the church, or other voluntary associations, except to guarantee the law and to prevent injustices.

In practical politics, Kuyper translated these ideas into the creation of the *Anti-Revolutionary Party* (1879) — the first mass political party in the Netherlands — the *Free University of Amsterdam* (1880) — a university explicitly founded on Calvinist principles, independent of the state and of the established church — and the system of confessional education subsidised by the state (*bijzondere scholen*), by which private schools of religious inspiration received public funding proportional to the number of enrolled pupils. This last

point was the core of the Dutch “school struggle” that dominated the country's politics for decades, being finally resolved by the Pacification of 1917, when the Dutch Constitution guaranteed equal funding for public and confessional schools — a system that persists to this day.

7 EVOLUTION UP TO THE PRESENT DAY

7.1 PILLARISATION (VERZUILING) AND ITS LEGACY

The social system that Kuyper helped to build — the so-called *verzuiling* (pillarisation) — became the dominant form of organisation of Dutch society in the twentieth century. The concept of pillarisation describes the division of Dutch society into parallel vertical ideological “pillars” (*zuilen*): an orthodox-Protestant (Calvinist) pillar, a Catholic pillar, a socialist pillar, and a liberal pillar, each with its own complete infrastructure of social, cultural, and political organisations. In its full development, around 1920–1960, pillarisation meant that a Dutch citizen could be born in a hospital of his pillar, be educated in schools of his pillar, work in a trade union of his pillar, read the newspaper of his pillar, listen to the radio of his pillar, and be buried by an undertaker of his pillar, without ever having significant contact with members of the other pillars.

The Protestant pillar, direct heir of the Calvinist tradition and of the work of Kuyper, exerted a formidable political and cultural influence during the first decades of the twentieth century. Kuyper's Anti-Revolutionary Party and its coalition partner, the Christian Historical Union, governed the Netherlands in coalition with the Catholic party during much of the interwar period. The Protestant confessional schools educated a significant proportion of Dutch youth. The Free University of Amsterdam, the University of Utrecht (with strong Reformed influence), and the Free University of Amsterdam trained generations of pastors, lawyers, doctors, and teachers who carried Calvinist values into all professions and instances of public life.

This system of pillarisation was, during its existence, remarkably effective in managing the religious and ideological diversity of a pluralist society. By ensuring that each major group had its own institutions subsidised by the state, it avoided the acute religious conflicts that had devastated other European countries. The “civil peace” that characterised the Netherlands during much of the twentieth century, in contrast to the religious or ideological civil wars of other countries, can be attributed in part to this system of “consociationalism” — the management of pluralism through the guarantee of institutional autonomy for each group.

7.2 SECULARISATION AND CONTEMPORARY SOCIETY

The most dramatic transformation of the Netherlands in the post-war period was the accelerated process of secularisation which, within a few decades, transformed one of the most deeply religious nations of Europe into one of the most secular in the Western world. This process, known as *ontzuiling* (de-pillarisation), refers both to the decline of individual religiosity and to the collapse of the system of pillars that had organised Dutch society during the twentieth century.

Dutch secularisation began slowly in the decades of the 1950s and 1960s, but accelerated dramatically after the cultural uprisings of 1968. The post-war generation, having grown up in unprecedented economic prosperity and educated to ever higher levels, began to question the traditional religious authorities. The concept of “emancipation” — of paradoxically Calvinist and socialist origin — which had been employed to describe the achievement of equality of rights by subaltern groups within the system of pillars, was redirected towards personal liberation from traditional moral and religious restrictions. Television, the universalisation of higher education, the expansion of the welfare state, and the international counterculture conspired to erode the communitarian loyalties that sustained the pillars.

The decline was especially pronounced among the Protestants. The Dutch Reformed Church (*Nederlandse Hervormde Kerk*), which had been the most influential institutional expression of Dutch Calvinism for centuries, saw its membership fall dramatically. In an attempt to reverse this decline through consolidation, the Dutch Reformed Church merged in 2004 with the Reformed Churches in the Netherlands (*Gereformeerde Kerken in Nederland*) and with the Evangelical Lutheran Church to form the *Protestantse Kerk in Nederland* (PKN). Despite the merger, the decline continued: in 2022, the PKN counted fewer than 1.6 million active members, compared with the nearly 4 million that the founding churches had had in previous decades.

The statistics of Statistics Netherlands (CBS) for 2022 reveal a radical transformation of the Dutch religious landscape: approximately 58% of the population over 15 years of age belonged to no religion, an expressive increase in relation to the 45% recorded in 2010. The Catholics represented about 18% of the population (a fall from 27% in 2010), while the Protestants totalled only 14% (a fall from 18% in 2010). The Muslims, whose presence is largely the result of the immigration of the 1960s–1980s, maintained a stable proportion of about 5%, with rates of religious observance significantly higher than those of the Christians. Among Dutch young people aged 18 to 25, fewer than 25% identified with any religion in 2022.

Table 2*Religious Profile of the Netherlands (2010–2022)*

Religious Affiliation	2010 (%)	2015 (%)	2022 (%)
No religion	45	52	58
Catholics	27	23	18
Protestants (PKN and others)	18	16	14
Muslims	5	5	5
Others (Hindus, Buddhists, Jews)	5	4	5

Source: Statistics Netherlands (CBS), 2022. Data referring to the population over 15 years of age.

Notwithstanding the secularisation of formal religious life, the cultural legacy of the Protestant Reformation remains deeply inscribed in the structures and values of contemporary Dutch society. The emphasis on education and literacy, which produced one of the most efficient educational systems in the world (with Dutch students consistently among the best in the international PISA rankings); the culture of tolerance and pluralism, which made the Netherlands a pioneer in the recognition of civil rights for minorities; the ethic of disciplined work and the meticulous management of resources, which manifests itself in the efficiency of Dutch agriculture and the solidity of its public finances; the commitment to international law and multilateral institutions, which has roots in the Grotian tradition of natural law; all these elements are, to a significant degree, secularised inheritances of the Calvinist culture that the Protestant Reformation implanted in the Netherlands.

8 LITERATURE REVIEW

The academic literature on the Protestant Reformation in the Netherlands and its impacts is vast and multidisciplinary, encompassing works of history, sociology, theology, economics, and political science. This section presents a critical review of the most relevant and influential works, organised by thematic axes.

8.1 THE THEOLOGICAL AND CULTURAL PERSPECTIVE

The work of **Abraham Kuyper**, especially the *Lectures on Calvinism* (conferences delivered at Princeton University in 1898 and published in 1899), remains indispensable for understanding the comprehensive cultural impact of Calvinism. Kuyper argued not merely about Reformed theology in the strict sense, but about Calvinism as a *Weltanschauung* — an integral worldview that generated specific implications for art, science, politics, and

economics. His analysis of Sphere Sovereignty continues to be a powerful theoretical framework for understanding the institutional plurality of modern democracies. The critique that may be made of Kuyper is that his vision is essentially apologetic and at times teleological, tending to present the Dutch developments as the necessary realisation of Calvinist principles, without sufficient attention to the contingent aspects and the non-religious forces that also shaped the Dutch trajectory.

Herman Bavinck (1854–1921), a contemporary and collaborator of Kuyper, offers a complementary perspective. In his monumental *Reformed Dogmatics* (4 volumes, 1895–1901), Bavinck articulates Calvinist theology systematically with a historical sensibility and an openness to dialogue with modernity that prefigure many theological developments of the twentieth century. Bavinck is particularly useful for understanding the relationship between Calvinist orthodoxy and the Erasmian humanist heritage, which Dutch Calvinism never completely abandoned.

8.2 THE SOCIOLOGICAL AND ECONOMIC PERSPECTIVE

The work of **Max Weber**, *The Protestant Ethic and the Spirit of Capitalism* (1904–1905), remains the obligatory point of reference for any discussion of the relations between Protestantism and economic development. Although many of his specific arguments have been contested by later research — especially his dating of the “capitalist spirit” and his characterisation of medieval capitalism — his central intuition concerning the relationship between religious ethics and economic behaviour continues to be fecund. The most sophisticated response to the Weberian thesis came from R. H. Tawney in *Religion and the Rise of Capitalism* (1926), which offers a more nuanced analysis of the relationship between Protestantism, Catholicism, and capitalism, avoiding the unilateral determinism of Weber.

For the Dutch case specifically, the unavoidable reference work is the monumental *The Dutch Republic: Its Rise, Greatness, and Fall 1477–1806* by **Jonathan Israel** (Oxford University Press, 1995). With more than 1,200 densely documented pages, Israel analyses the rise and decline of the Dutch republic as a multifactorial phenomenon, in which the Protestant Reformation is one among several determining elements, including the geographical structure (the Rhine delta), the naval innovations, the pre-existing urban tradition, and the geopolitical conjunctures. Israel is particularly useful for understanding the internal tensions of the republic and the factors that eventually led to its decline in the eighteenth century.

Geoffrey Parker, in *The Dutch Revolt* (1977), offers the most detailed and balanced analysis of the Eighty Years' War, situating it in the broader context of the European wars of

religion and the crisis of the Habsburg system. Parker examines both the religious and the political, social, and military dimensions of the conflict, demonstrating that the victory of the Dutch revolution was contingent and dependent on a specific combination of factors that would hardly be repeated.

8.3 THE PERSPECTIVE OF EDUCATION AND LITERACY

Tyrel C. Eskelson, in “States, Institutions, and Literacy Rates in Early-Modern Western Europe” (2021), published in the *Journal of Education and Learning*, offers the most recent and methodologically sophisticated quantitative analysis of the relationship between Protestantism and literacy. Using data from multiple countries over the period 1500–1800 and controlling for economic and urban variables, Eskelson confirms the existence of a “Protestant effect” on literacy that is statistically robust, especially in the case of the Calvinist nations. The work is required reading for any researcher who wishes to go beyond generalisations and work with rigorous empirical evidence.

The classic work of **Harvey J. Graff**, *The Legacies of Literacy: Continuities and Contradictions in Western Culture and Society* (1987), provides the broader context for understanding the reading revolution in modern Europe. Graff demonstrates that the relationship between literacy and Protestantism, although real, was mediated by a series of other factors — urbanisation, economic development, typographical tradition — that made Protestantism a facilitating condition, not a sufficient condition, for mass literacy.

8.4 THE CONTEMPORARY PERSPECTIVE

For the analysis of contemporary Dutch secularisation, the works of **Peter Berger** are essential. In *The Sacred Canopy* (1967) and in later works such as *The Desecularization of the World* (1999), Berger revised his initial thesis on secularisation as an inevitable consequence of modernity, recognising that the Netherlands is an exceptional case within a world that, globally, remains deeply religious. This revision offers a valuable comparative perspective for understanding why Dutch secularisation was more profound and rapid than in many other Protestant countries.

The works of the Dutch sociologist **Peter Achterberg** and collaborators on the “Dutch paradox” — how a country with such deep Calvinist roots secularised so completely — represent the most current empirical research on this phenomenon, using data from longitudinal surveys of Statistics Netherlands to trace the religious transformations of Dutch society over the decades.

9 BENEFITS OF THE RESEARCH

The investigation of the impact of the Protestant Reformation on Dutch development offers benefits that transcend historical interest in the strict sense, projecting themselves onto fundamental questions of contemporary debates in the sociology of religion, political science, the theory of economic development, and the philosophy of education.

For the Sociology of Religion and the Theory of Secularisation: The Dutch case is a privileged historical laboratory for testing the hypotheses on the relationships between religion and modernity. The trajectory that goes from the most fervent of the Calvinist nations of the seventeenth century to the most secularised society of contemporary Europe challenges the simplistic versions of the secularisation thesis — which predicted a linear relationship between modernisation and the decline of religiosity — while at the same time illustrating the mechanisms by which a religious tradition can gradually produce the conditions of its own supersession. The Calvinist emphasis on education and critical reading produced generations of literate citizens capable of questioning religious authority itself; the doctrine of sphere sovereignty, by limiting the power of the Church over the state and civil society, created the autonomous spaces from which secularisation could advance.

For the Theory of Economic Development: The Dutch experience demonstrates the importance of institutional and cultural variables in economic development, complementing and at times challenging the analyses that privilege geographical, technological, or resource-endowment factors. Investment in education as a factor of economic development — today an axiom of development economics — finds one of its most eloquent historical examples in the Holland of the seventeenth century, where mass literacy, motivated by religious reasons, created a workforce of high productivity and a mercantile class capable of financial and organisational innovation. The creation of the VOC as a joint-stock company, of the Bank of Amsterdam as a precursor of the central bank, and of the Amsterdam Stock Exchange as the first organised capital market are institutional innovations whose cultural roots go back, at least in part, to the Reformed tradition of community organisation, accountability, and collegial management.

For Political Science and Democratic Theory: The republican system of the United Provinces anticipated many of the characteristics that we consider essential to modern democracies: representation, federalism, checks and balances, tolerance of minorities, independence of the judicial power. The analysis of the theological bases of this system — the Calvinist distrust of unrestricted human power, the doctrine of sphere sovereignty, the tradition of collegial ecclesiastical government — contributes to the understanding of the cultural foundations of liberal democracies, a subject of growing relevance in an era of rising

authoritarianism. Kuyper's doctrine of Sphere Sovereignty, in particular, offers a conceptual framework alternative to the liberal social contract of Locke and Rousseau for grounding political pluralism and the limitation of state power, with direct implications for contemporary debates on the role of religion in democracy.

For Theology and the Church: This study demonstrates, with robust historical evidence, that doctrinal fidelity and social engagement are not mutually exclusive alternatives. Dutch Calvinism was, simultaneously, rigorously orthodox in its doctrinal standards (the Canons of Dort, the Belgic Confession, the Heidelberg Catechism) and profoundly transformative of the society in which it was inserted. This combination challenges both the pietism that divorces faith from civic engagement and the social activism that sacrifices doctrinal depth in favour of immediate relevance. The Dutch model suggests that a community of faith that takes seriously both its theology and its responsibilities towards the creation of God can be a powerful agent of civilisational transformation.

For the Educational Sciences: The Dutch educational revolution of the seventeenth century offers historical evidence for the thesis that the best educational systems are those that are rooted in a coherent and motivating vision of human dignity and destiny. The Dutch school was not merely an institution for the transfer of technical information; it was the space for the formation of a civic and spiritual identity, for the transmission of values, and for the creation of a community of persons capable of reading, thinking, and participating actively in public life. This integral vision of education — which rejects both pure instrumentalism (education as preparation for the labour market) and narrow ideologism (education as indoctrination) — has much to offer to contemporary educational debates.

10 CONCLUSION

The historical journey analysed in this article confirms and expands the central thesis that motivated the investigation: the Protestant Reformation, in its specific Calvinist form, was a first-order civilisational engine in the development of the Netherlands. Starting from the first Lutheran and Anabaptist infiltrations of the 1520s, passing through the theological and organisational systematisation brought by figures such as Guido de Brès, Jan Łaski, and John Calvin, up to the dramatic consolidation in the forge of the Eighty Years' War and the intellectual crucible of the Synod of Dort, Dutch Calvinism forged a nation whose influence on the development of Western modernity is inversely proportional to its geographical size.

The impacts identified and analysed throughout the sections of this article may be synthesised into four fundamental dimensions:

In the first place, the **educational dimension**: the principle of *Sola Scriptura* and the doctrine of the priesthood of all believers transformed literacy from an elite privilege into a universal spiritual necessity, producing the highest literacy rates in Europe in the seventeenth century and establishing the model of public education that the following centuries would only refine. The *Statenvertaling* of 1637 linguistically unified the nation and provided the textual basis for an unprecedented intellectual revolution.

In the second place, the **economic dimension**: the Protestant ethic of work as a divine vocation, of inner-worldly asceticism, and of the systematic reinvestment of the surplus created the cultural conditions for the accumulation of capital and the institutional innovation that defined the Golden Age. The VOC, the Bank of Amsterdam, the Amsterdam Stock Exchange — all these institutional innovations that shaped modern capitalism emerged from a cultural environment profoundly marked by Reformed values.

In the third place, the **political dimension**: the Calvinist distrust of absolute human power, grounded in the doctrine of total depravity, was the theological substrate of an innovative republicanism that anticipated central elements of modern liberal democracies. The Act of Abjuration of 1581, by grounding the legitimacy of government in respect for the rights of the governed, foreshadowed Locke and, through him, the declarations of independence of the eighteenth century. Kuyper's doctrine of Sphere Sovereignty articulated this Reformed intuition systematically into a political philosophy of high contemporary relevance.

In the fourth place, the **cultural and identity dimension**: Dutch Calvinism not only produced institutions and behaviours; it produced a culture — a constellation of values, practices, narratives, and symbols — that shaped the collective character of the nation in an enduring manner. The pragmatic tolerance of Amsterdam, the moral seriousness of the Dutch bourgeoisie portrayed in the group portraits of Rembrandt and Hals, the scientific meticulousness of van Leeuwenhoek and Huygens, the legal sagacity of Grotius — all these expressions of the Dutch genius of the Golden Age are unthinkable without the cultural underpinning that Calvinism provided.

The subsequent trajectory of the Netherlands — from the Calvinist fervour of the seventeenth century to the almost complete secularisation of the twenty-first century — does not invalidate this legacy; rather, it transforms it into a fascinating paradox. A religious tradition that valued education, critical reason, the questioning of authorities, and the autonomy of the individual before God prepared the ground, inadvertently, for its own supersession by secular modernity. The values of tolerance, pluralism, universal education, and limitation of state

power, which the Reformation implanted in Dutch culture, survived and prospered even when the religious faith that had generated them retreated to the margins of public life.

This is, perhaps, the most profound teaching of the Dutch case: ideas have consequences that transcend the intentions of their authors and the currency of the beliefs that generated them. The Protestant Reformation in the Netherlands was a singular historical event, unrepeatable in its specific form, but whose lessons for the present are perennial: education as the commitment of a community to its own future; the limitation of power as a safeguard of human dignity; tolerance as a condition of collective prosperity; and faith — any authentic faith — as a force capable of moving not only mountains, but entire nations.

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PRESIDENTIALISM AND DEMOCRACY IN LATIN AMERICA

PRESIDENCIALISMO E DEMOCRACIA NA AMÉRICA LATINA

PRESIDENCIALISMO Y DEMOCRACIA EN AMÉRICA LATINA



10.56238/sevened2026.019-115

José Lucio Santos Gorayeb¹**ABSTRACT**

This paper addresses the concepts of Latin America, democracy and presidentialism, including coalition presidentialism, providing a brief comparison with Parliamentarism. It presents impressions published in scientific articles and the media regarding the impeachment of the Brazilian President Dilma Roussef and the trial/conviction of Jair Bolsonaro for attempting a coup d'état. The objective is to theoretically examine the relationship between presidentialism, democracy and Latin America, while analysing the two aforementioned cases. The methodology employed is bibliographic, relying on books, scientific articles, and trial records. The study concludes that in presidentialism, it is necessary for the President to possess special political skills to remain in office, but the respect for constitutional rules is a must.

Keywords: Presidentialism. Democracy. Latin America. Impeachment. Coup D'État.

RESUMO

Este artigo aborda conceitos de América Latina, democracia e presidencialismo, incluindo o presidencialismo de coalizão. Faz-se breve comparação com o Parlamentarismo. Traz-se impressões publicadas em artigos científicos e nos média acerca do impeachment sofrido pela Presidenta do Brasil Dilma Roussef e no julgamento e condenação do Presidente Jair Bolsonaro por golpe de estado, dentro outros crimes. O objetivo é tratar teoricamente da relação entre presidencialismo, democracia e América Latina, além de analisar os casos mencionados. A metodologia é bibliográfica (livros, artigos científicos e atas de julgamento). Conclui-se que no presidencialismo é necessário que o Presidente tenha especial habilidade política para conseguir se manter no poder, mas o respeito às regras constitucionais e legais é de rigor.

Palavras-chave: Presidencialismo/ Democracia. América Latina. Impeachment. Golpe de Estado.

RESUMEN

Este artículo aborda los conceptos de América Latina, democracia y presidencialismo, incluido el presidencialismo de coalición. Se realiza una breve comparación con el Parlamentarismo. Se presentan impresiones publicadas en artículos científicos y en los medios de comunicación acerca del impeachment sufrido por la Presidenta de Brasil Dilma Roussef y sobre el juicio y condena del Presidente Jair Bolsonaro por golpe de estado, entre otros delitos. El objetivo es tratar teóricamente la relación entre presidencialismo, democracia y América Latina, además de analizar los casos mencionados. La metodología es bibliográfica (libros, artículos científicos y actas de juicio). Se concluye que en el presidencialismo es necesario que el Presidente posea especial habilidad política para lograr mantenerse en el poder, pero el respeto a las reglas constitucionales y legales es de rigor.

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1 INTRODUCTION

The proposed theme combines three topics whose definitions are, in the case of the first, easier to understand and more uniformly defined among authors. *Democracy* and *Latin America*, however, require somewhat more debate concerning their nature and contours. The present *paper* will begin by addressing the concepts of each topic, passing through some problematisation or theoretical variation, limiting itself to mentioning specific examples of questions linked to real cases that occurred in the region.

Although in the title Latin America comes in third place, it was decided to begin the text by trying to understand what it is, its emergence and geopolitical context.

Subsequently, presidentialism will be dealt with based mainly on Juan Linz and Scott Mainwaring. It is impossible, on the other hand, to speak of presidentialism without recalling the separation of powers, for which the theory disseminated by Montesquieu is unavoidable. A brief description is made of “coalition presidentialism”, the Brazilian case. The advantages and disadvantages of the system of government unanimously chosen in this part of the globe are discussed. As a counterpoint, parliamentarism is superficially addressed.

Regarding democracy, an approach is taken concerning its varied meanings, from Abraham Lincoln, Robert Dahl and Guillermo O'Donnell.

The methodology used is bibliographic research (articles and books). It is concluded that political instability is quite present in the region, that the presidentialist system requires special political skill from the office-holder, and that it opens opportunities for authoritarianism.

2 LATIN AMERICA

For the purposes of the “regional report on Latin America and the Caribbean” of 2001, by the UNESCO Institute for Statistics of 2001, the term Latin America is a convention; it generally refers to that group of countries of continental America and the Caribbean whose inhabitants speak Spanish or Portuguese, composed of 19 republics: Argentina, Bolívia, Brasil, Chile, Colômbia, Costa Rica, Cuba, República Dominicana, Ecuador, El Salvador, Guatemala, Honduras, México, Nicaragua, Panamá, Paraguai, Peru, Uruguai and Venezuela.

It must not be forgotten that, in addition to the languages of the coloniser, many languages of the indigenous peoples are spoken in the region.

Bethell (2009) affirms that the term derives from the French *Amérique Latine*, used at the beginning of the 1800s by French intellectuals to refer to imperialism in Mexico under Napoleon III. However, Morse (1988) argues that Napoleon III would only have used this term 400 years after the discovery of the West Indies, with the aim of creating an alleged linguistic

and cultural unity of the Latin peoples, in opposition to Germanic, Anglo-Saxon and Slavic peoples.

Espinosa-Dassonneville (2022) asserts:

[...] le mot et l'idée d'« Amérique latine » ont été utilisés la première fois à Paris en 1856 sous la plume des écrivains Francisco Bilbao (Chilien) et José María Torres Caicedo (Colombien). Au nom d'une « conscience » latino-américaine, éveillée grâce à l'antithèse saxon/latin, ils dénoncent le matérialisme et l'impérialisme des États-Unis qui prétendent apporter le progrès et la civilisation [...]. Enfin, c'est le diplomate argentin Carlos Calvo qui a utilisé officiellement l'expression « Amérique latine » pour son *Recueil complet des traités* publié à Paris (1862) et dédié à Napoléon III, « le souverain de l'Europe qui a le mieux compris toute l'importance de l'Amérique latine »².

The concept of Latin America is born as a term in favour of the political and economic interests of Napoleon III, as well as by the need to impose France as a counterpoint against the growing influence of the United States. It is these geopolitical circumstances that will give rise to the idea according to which Latin America is a French invention, because in fact France was primarily the promoter and disseminator of the concept (TORRES MARTINEZ, 2016)

3 DEMOCRACY

In antiquity, in Herodotus, Democracy was a form of government, alongside other forms of government: monarchy (the government of only one) and aristocracy (the government of a few) (ROSENFELD, 1984).

The French Revolution retook the classical Greek notion of democracy, giving the world the modern notion of the State. The influence of France on what is understood by politics, State and democracy is vast. Eric Hobsbawm teaches, regarding the political conformation of the modern State:

If the economy of the nineteenth-century world was formed mainly under the influence of the British industrial revolution, its politics and ideology were formed fundamentally by the French Revolution. Great Britain provided the model for the railways and factories, the economic explosive that broke down the traditional socio-economic structures of the non-European world; but it was France that made its revolutions and gave them their ideas, to the point that tricolour flags of one kind or another became the emblem of virtually every emerging nation, and European (or even world) politics between 1789 and 1917 was largely the struggle for and against the principles of 1789, or the even more incendiary ones of 1793. France provided the vocabulary and the themes of liberal and radical-democratic politics for most of the world. France gave the first great example, the concept and the vocabulary of nationalism. France provided the legal codes, the model of technical and scientific organisation and the

² In free translation: The word and the idea of "Latin America" were used for the first time in Paris, in 1856, by the writers Francisco Bilbao (Chilean) and José María Torres Caicedo (Colombian). In the name of a Latin American "consciousness" awakened by the Saxon/Latin antithesis, they denounce the materialism and imperialism of the United States, which claim to bring progress and civilization [...]. Finally, it was the Argentine diplomat Carlos Calvo who officially used the expression "Latin America" in his work "*Recueil complet des traités*", published in Paris in 1862 and dedicated to Napoleon III, "the sovereign of Europe who best understood the full importance of Latin America".

metric system of measurement for most countries. The ideology of the modern world reached the ancient civilisations which had until then resisted European ideas initially through French influence. This was the work of the French Revolution (HOBBSAWM, 1962).

The French Revolution is a landmark in every country. Its repercussions, unlike those of the American revolution, brought about the uprisings that led to the liberation of Latin America after 1808 (Hobsbawm, 1962).

Some meanings that are held of the term Democracy are: a) democracy is “the government of the people, by the people and for the people”, which appeared in Abraham Lincoln's speech at a ceremony held in Gettysburg on 19/11/1863 (Lincoln, 1863); b) democracy as a deliberative process: this concept holds that democracy is not only a matter of elections of political representation, but also of dialogue and deliberation among free and equal citizens (Habermas et. al, 1996); c) democracy as equality of opportunity: this concept focuses on the idea that democracy must guarantee equality of opportunity for all citizens, regardless of their social and economic origins (Rawls, 1971); d) participatory democracy: this concept highlights the importance of the active participation of citizens in political decision-making and public management, going beyond the simple right to vote and elect representatives (Santos, 2005); e) democracy as political culture: these views emphasise the importance of a democratic political culture, with values and practices that promote tolerance, dialogue, diversity and social justice (SEN, 2010).

Oliveira (2020) argues that the classical models proposed by the theoretical currents of transitology and consolidology do not explain Latin America, the model of delegative democracy being the one closest to the reality of the region.

The models of consolidology and transitology are two theoretical approaches used to analyse the process of democratic consolidation and transition in different countries. Consolidology departs from the idea that democracy is a gradual process, in which political institutions are consolidated over time, whereas transitology understands the transition to democracy as an abrupt and singular process.

In Latin America, the theories of consolidology and transitology were widely used to analyse the process of democratisation in different countries of the region. Linz & Stepan (1996) argue that the region underwent an incomplete democratic transition, characterised by institutional fragility and by the weakening of civil society. Mainwaring & Pérez-Liñán (2013) hold that democracy in the region is marked by the persistence of authoritarian practices and by political corruption.

Among the enormous and often impenetrable thickets of ideas about democracy, Dahl (1998) states that there are at least 5 criteria for considering that democracy exists, using a fictitious association as an example:

- a) Effective participation: before a given policy is adopted, all members must have equal and effective opportunities to give their view to the other members concerning such policy;
- b) Equality in voting: at the moment of deciding which policy to adopt, each member must have an equal and effective opportunity to vote, and all votes must have the same weight;
- c) Enlightened understanding: within reasonable limits of time, each member must have equal and effective opportunities to learn more about the alternative policies and their probable consequences;
- d) Control of the agenda: the members must have the exclusive opportunity to decide how and, if they prefer, which matters will be part of the agenda. In this way the democratic process required for the first three criteria is never closed. The Association's policies are always open to changes, if the members so decide;
- e) Inclusion of adults: most, if not all permanent adult residents must have full rights of citizens that are implicit in the first four criteria. Before the twentieth century this criterion was not accepted by most defenders of democracy. (MAINWARING & PEREZ-LIÑAN, 2013).

O'Donnell (1994) establishes his criteria for verifying the democracy of a country:

1. Free and fair elections: Citizens must have the right to vote in elections that are free and fair, without coercion or intimidation, and where each citizen's vote has the same weight.
2. Popular participation: Democracy must allow the active participation of citizens in political life, not only through elections, but also through other forms of participation, such as protests, petitions and referendums.
3. Respect for civil liberties: Democracy must guarantee freedom of expression, freedom of association and freedom of the press, in addition to protecting human rights and minorities.
4. Accountability of the government: The government must be accountable to the people and subject to laws that limit and control its power.
5. Control of power: Democracy must guarantee the separation of powers and the existence of independent institutions, such as the judiciary and the press, which can oversee and limit the power of the government. (O'DONNELL, 1994).

Oliveira (2020) reports that O'Donnell (1988) added three criteria to his five aforementioned ones: “(6) elected authorities must not be removed before the end of the mandate; (7) elected officials cannot be subject to non-elected officials, such as the armed forces and; (18) territory that clearly defines the voting position”.

4 PRESIDENTIALISM

Montesquieu (2008) teaches that there are three species of government: Republic (in which the people in general, or only a part of them, holds sovereign power); Monarchy (in which only one governs, but by fixed and established laws); Despotism (a single one, without law and without rule, does everything by his own will and his caprices).

Paul Janet, editor of *The Spirit of the Laws*, clarifies that the first thinker to mention the separation of powers was Aristotle, reproduced by Locke and repeated by Montesquieu (Montesquieu, 2008). It is important to bear in mind the separation of powers, because presidentialism is generally based on this idea (CHEIBUB et.al., 2017)

A presidentialist democracy has two characteristics. First, the head of government is elected independently of the parliament, that is, legislative elections and post-electoral negotiations do not determine the executive power (unlike Parliamentarism, where post-electoral negotiations will define which parties will govern and who the leaders will be). The head of the executive is normally elected by popular vote (but there are exceptions, such as the United States, where the vote takes place by electoral college, but even there the popular vote conditions the electoral college). The second characteristic of presidentialist democracies is that the President is elected for a fixed-term mandate, although most democracies exceptionally permit *impeachment*. The President cannot be deposed by a vote of no confidence of the parliament, so that the president cannot be formally held accountable by Congress (MAINWARING, 1990).

Presidentialism is defined by at least one of the following criteria: a) election of the Head of State by popular choice, direct or indirect and for a fixed period; b) the Parliament cannot appoint nor reappoint the government; c) the Head of State is also the Head of Government. However, for there to be so-called “pure presidentialism” these must be present at the same time. Thus, a system is presidentialist if, and only if, i) the choice of the president results from popular elections, ii) during the mandate he cannot be dismissed by the parliamentary vote and iii) he heads the government or governments appointed by himself (SARTORI, 1992).

In comparison, in a parliamentary system, the head of government is elected by the Legislature and, consequently, depends on the confidence of the latter over time to remain in

the function, and for this reason the period is not fixed. This idea also approximates French semi-presidentialism, for example, where the executive power is divided between the President (elected by the people) and the Prime Minister (MAINWARING, 1990).

Bobbio *et al* (1998) teach that “the classical bipartition distinguishes the parliamentary Form of Government and the presidential Form of Government”, presidentialism being typical only of the republican system, whereas parliamentarism (or, as the author prefers, the Parliamentary Form of Government) can be found both in monarchical systems and in republican systems.

Latin America had parliamentarist governments in Brazil (1961-1963) and in Chile (1891-1924), but “the Latin American experiences sometimes called parliamentarism are in reality presidentialist systems” (MAINWARING, 1990, p. 159).

America (not only Latin America) is the stage of a totally original structure regarding the very clear separation between the Executive and the Legislature, which is the presidentialist regime. In the parliamentarism seen in Europe, this differentiation between who exercises the executive function and the legislative function is much less accentuated, “inasmuch as the Government is composed of deputies, who answer for their action, directly before the assembly or assemblies and, only indirectly, before the elections” (BOBBIO *et. al*, 1998, p. 249)

As the democracies of Western Europe presented stability and strong economic development, whereas in Latin America there were coups d'état, autocratic governments and military dictatorships – in addition to the serious social and economic problems of the region –, these problems are associated with presidentialism. Linz understands that presidentialism, as another characteristic, hinders accountability. How, he asks, is one to punish through the vote a president who can no longer be re-elected? The punishment would fall on the party, which is not fair, since the president may have governed with independence from party ties. In any case, the voters have to wait for the end of the mandate to demand accountability, whereas in parliamentarism the vote of censure can be presented against the prime minister by the Parliament and by his own party.

Juan Linz is critical of presidentialism, basing himself on five factors: 1) the president and the parliament fight for legitimacy; both are elected by popular vote, so that the survival of each is independent of the other; 2) the fixed-term mandate offers a rigidity less favourable to democracy than the flexibility offered by parliamentarist systems; 3) presidentialism introduces an “all or nothing”, where one wins and the other loses, whereas in parliamentarism there is a division of power and a formation of coalition where even the smaller parties obtain something for themselves; 4) the style: the president being the

representative of the whole nation may make him intolerant of the opposition; the sensation of having an independent mandate, granted by the people, may generate an excessive idea of power and divert him from the perception that he was elected by a plurality; 5) the “outsiders” are more prone to win the office, with destabilising powers. These lessons of Linz are contained in Mainwaring and Shugart (1997).

On the fight for legitimacy between President and Legislature in presidentialism, which he denominates “dual power”, Linz teaches:

“Sin entrar en la complejidad de la relación entre el ejecutivo y el legislativo en distintos regímenes presidenciales, los peligros relativos del predominio de uno o otro y la capacidad de vetar o paralisar decisiones sobre legislación, no cabe duda de que los regímenes presidenciales están basados en una legitimidad democrática dual y que ningún principio democrático puede decidir quién representa la voluntad popular en principio. En la práctica, y especialmente en países en vías de desarrollo con grandes desigualdades regionales en modernización, es muy probable que la composición y las opiniones políticas y sociales del legislativo sean distintas de las de los que apoyan al presidente” (LINZ *in* LINZ & VALENZUELA, 1998, p.35).

On the legal difference between presidentialism and parliamentarism, Bobbio teaches:

At a more superficial level is placed the distinction founded on the juridical-institutional criterion between presidential regime and parliamentary regime. The difference between the two regimes lies in the different relationship between legislature and executive. Whereas in the parliamentary regime the democraticity of the executive depends on the fact that it is an emanation of the legislature, which, in turn, is based on the popular vote, in the presidential regime the head of the executive is elected directly by the people. In consequence of this he renders accounts of his action not to the Parliament but to the voters who can sanction his political conduct by denying him re-election. (Bobbio, 1998, pg 327).

It is worth mentioning that Cadena and Gayoso bring the thinking of Nolan, Carpizo and Zovatto & Orozco, regarding the difference between hyperpresidentialism, pure presidentialism and attenuated presidentialism, as follows: in hyperpresidentialism the Constitution confers upon the president a considerable amount of powers; in pure presidentialism the original characteristics are maintained; in the attenuated one, the powers are constitutionally balanced between Executive and Legislature; whereas parliamentarised presidentialism incorporates mechanisms proper to parliamentarist systems, such as the vote of censure against ministers, the ratification of some members of the cabinet by the Legislature and the permanence of a collegiate Executive (Nohlen, 1998; Zovatto and Orozco, 2009; Carpizo, 1978, *in*: Cadena and Gayoso, 2016).

Let us deal with Coalition Presidentialism, a term coined by Sérgio Abranches in an article published in the year of the promulgation of the most recent Constitution of Brazil, 1988. According to the author, Executive and Legislature are always in conflict, this conflict

having as its basis 5 historical formative elements of the arrangement between the institutions: presidentialism, federalism, bicameralism, multipartism and proportional representation. (1988).

The coalition presidentialism that takes place in Brazil is unique in the world. Most of the democracies of the second post-war period are parliamentarist, the United States being the only purely presidentialist one. France presided over by De Gaulle was presidentialist, but of the mixed type, where the parliament could dismiss the ministry. Finland is technically considered a cabinet regime, since the presidential cabinet can be dissolved by the parliament. In Switzerland there is no vote of confidence, but it is a Federal Council of seven members elected by the parliament that is the head of the Executive. (ABRANCHES, 1988).

Brazil has many political parties because its cultural and social variety is enormous. There is a correlation between party fragmentation, social diversity and greater probability of large coalitions. "Brazil is the only country that, in addition to combining proportionality, multipartism and 'imperial presidentialism', organises the Executive on the basis of large coalitions" (ABRANCHES, 1988, p. 21).

The author published a new work on the theme, 30 years after the article above, that is, 2018. He seems to declare that coalition presidentialism would be a kind of hybrid system of government, with the fusion of characteristics of presidentialism and parliamentarism, as follows:

"It is no surprise that in the impasse between parliamentarists and presidentialists the compromise solution converged towards coalition presidentialism. Not as a preferential choice, but rather by reciprocal rejection of the alternatives. In the Brazilian circumstances, the choice for multiparty presidentialism materialises in coalition presidentialism" (ABRANCHES, 2018).

5 HOW TO DISMISS THE PRESIDENT? THE CASE OF DILMA ROUSSEFF

Since the president is elected for a fixed term, an established period, it is not part of the normal plans to dismiss this president, who has the right to fulfil their mandate, in respect of the votes received. However, the motion of censure, typical of parliamentarism, was gradually being inserted into the constitutions of 14 countries of Latin America, with the exception of Brazil, Chile, Honduras and Mexico. As for the vote of confidence, it was implemented only by Peru, the Dominican Republic and Uruguay (Cadena and Gayoso, 2016).

Ganghof argues that the methods for dismissing a president should be feasible and effective, as follows:

Given the direct power that modern chief executives have over their citizens, their dismissal should be feasible and effective. Direct recall and impeachment do not score highly on these criteria (e.g. Ginsburg *et al.* 2020; Pérez-Liñán 2020). The most

fundamental reason is arguably the same for both procedures: they often lack what we might call political neutrality. That is, they are extraordinary procedures that tend to inexorably connect the ousting of the chief executive to the more general power struggle between competing political forces in society. They are, in fact, not just procedures for replacing the chief executive but potentially allow the losers of the last election to change the electoral outcome or, at least, to hurt the winners politically. This lack of neutrality can give rise to deeply divisive and traumatic struggles between the political forces that support presidents and those that oppose them (Ganghof, 2021, pg. 156)³.

For those who defended the impeachment of President Dilma, the legal arguments needed to demonstrate that she had committed the crime of responsibility. The points alleged in the petition were a) fiscal manoeuvres, not provided for in law, carried out by the government, consisting of the delay in the transfer of funds from the National Treasury to private and public banks, in order to relieve the government's fiscal situation for a certain time (these measures became known as “fiscal pedalling”); b) issuance of decrees establishing the release of supplementary credits without authorisation from the Parliament. Thus, she would fall under the Law of Responsibility (No. 1079/50, which defines the crimes of responsibility and regulates the respective process and trial of presidents of the republic).

In her defence, sponsored by the Advocacia-Geral da União, Dilma Rousseff alleges that the *impeachment* process is in fact a coup d'état. Let us look at an excerpt:

It is common to use the expression “coup d'état”, in all continents (“Coup d'État”, “Staatsreich”), to define the situations in which the deposition occurs, by means not admitted by the legal order, of a legitimate government. Although, on the historical plane, the materialisation of coups by force of arms is more common, one also cannot ignore that, many times, and especially in the days that follow, such institutional ruptures are woven and executed under the apparent mantle of “legality”. This will occur whenever, under the rhetorical allegation of the occurrence of situations that in fact do not exist or do not justify in law the cassation of a presidential mandate, legal subterfuges, unfounded and unwarranted arguments are sought for the apparent legal legitimisation of the deposition of a government, without there being any constitutional basis for that. In these cases, tanks, bombardments, cannons or machine guns will not be used. False, mendacious legal arguments will be used, seeking to replace the violence of armed actions with the hollow and hypocritical words of those who feign to be democrats the better to trample democracy at the moment when this serves their interests. The Constitution is invoked, only for it to be torn up with elegance and without noise. (Camara Legislativa, 2016).

This trial, as is known, is essentially political, even though it is necessary to fit the conduct of the president, in the case of Brazil, within the Law of Responsibility. The votes of the 367 parliamentarians in favour of the impeachment, nevertheless, had as their foundation motives that were not at all legal, such as God, family, homage to a torturer, respect, conscience. Certainly, the word corruption was much used in the votes (in tune with the word used many and many times in the mainstream media), but outside its legal sense. At no point, in the votes, was an article of law sought that describes an act of corruption (however there

³ In free translation

exists Law No. 12,946 of 2013, which brings acts harmful to the National or Foreign Public Administration in articles 5 and following). Once the process was admitted in the Chamber of Deputies, the process went to the Federal Senate, where it was confirmed as admissible, by 59 Senators in favour, 21 against, no abstention (Senado Federal, 2016).

The final sentence, in its operative part (that is, the decisive part, without the long reports), was as follows:

The Federal Senate understood that Madam President of the Republic Dilma Vana Rousseff committed the crimes of responsibility, consisting of contracting credit operations with a financial institution controlled by the Union and issuing supplementary credit decrees without authorisation from the National Congress, provided for in art. 85, item VI, and art. 167, item V, of the Federal Constitution, as well as in art. 10, items 4, 6 and 7, and art. 11, items 2 and 3, of Law No. 1,079, of 10 April 1950, by 61 votes, there having been registered 20 votes against and no abstention, the accused being thus condemned to the loss of the office of President of the Federative Republic of Brazil.

In a subsequent vote, the Federal Senate decided to set aside the penalty of disqualification from the exercise of public office, by virtue of not having obtained in this vote the two thirds of the votes constitutionally provided for, there having been verified 42 votes favourable to the application of the penalty, 36 against and 3 abstentions.

This sentence, drawn up in the records of the process, shall appear in a resolution of the Federal Senate, shall be signed – the sentence – by me and by the Senators who functioned as judges, transcribed in the minutes of the session and, within these, published in the *Diário Oficial da União*, in the *Diário do Congresso Nacional*, according to art. 35 of Law No. 1,079, and in the *Diário do Senado Federal*.

Such decision formally concludes the *impeachment* process instituted against the President of the Republic in the Federal Senate, on 12 May 2016.

Let the communications be made to His Excellency the acting President of the Republic, to Their Excellencies the Presidents of the Chamber of Deputies, of the Federal Senate and to Her Excellency the Vice-President of the Federal Supreme Court, 31 August 2016. I sign the sentence. (*Applause.*) (Senado Federal, 2016).

It is noted that in Brazil this type of trial, as already mentioned, is political, so that it may be said that the legal argumentation is a mere excuse for the application of the sanction. This overlap would make sense if *impeachment* in Brazil were treated as *recall* and not as a crime of responsibility. However, Masturcelli (2020) points out that this expedient serves as political blackmail and even as a “constitutional coup” against a president of the Republic, it being sufficient to “count on the activism or acquiescence of the Judiciary, legitimising the thesis that everything is working as the Federal Constitution preaches, and the qualified majority of 2/3 in the National Congress coming to approve the process” (MASTURCELLI, 2020).

6 JAIR BOLSONARO: THE FATEFUL 8 JANUARY 2023

After the result of the ballots in the Brazilian general elections of October 2022 had announced that Luis Inácio Lula da Silva had come out the winner, Jair Bolsonaro and his accomplices decided to gather a crowd to invade and vandalise the Federal Supreme Court, the Palácio do Planalto (seat of the Executive Power) and the National Congress.

It was evidently a quite prepared movement and with the necessary anticipation. Between 4 and 5 thousand people (Costa, 2024) marched towards the Praça dos Três Poderes. Probably the leaders of this criminal march were inspired by Donald Trump, who had previously led an invasion of the Capitol, in Washington. Unlike the United States of America, however, Brazil tried its perpetrators, ending up convicting them.

At 8:20 a.m., alerts from the Brazilian Intelligence Agency reported the arrival of 101 buses in Brasília. At 10 a.m., a new alert regarding the arrival of demonstrators, with incitements to move towards the Esplanada dos Ministérios. At 1 p.m., a march with thousands of people set out from the camp of the Setor Militar Urbano (Costa, 2024).

At 1:23 p.m. the substitute of the Secretary of Public Security of the Federal District sends an audio to the then Governor of the Federal District, Ibaneis Rocha, reassuring him. At 3:12 p.m. Military Police of the 2nd Riot Policing Platoon arrived at the Congress, but did not repress the invaders, having even gone so far as to make gestures for them to proceed (Costa, 2024).

The invaders, saying that they did not accept the result of the elections, used violence against property of inestimable and above all symbolic value. Inside the buildings, they broke furniture, tore works of art off the walls, destroyed glass windows, lamps, chairs, carpets. They filmed their actions and proudly posted them on social networks (which greatly helped in the police investigations).

The Federal Supreme Court accounted for losses exceeding twelve million reais, with 951 items stolen, broken or completely rendered useless. In the Congress, a loss of almost 5 million reais; in the Palácio do Planalto, registered damages of more than 4 million reais. In money, a loss of 21 million reais – or approximately 3.5 million euros – caused in a single afternoon (MPF, s.d.).

Several authorities were convicted, among them military personnel of the highest rank, but we shall focus our attention on the conviction of the former President Bolsonaro, since the scope of the present article is presidentialism.

If the crimes of damage and destruction of public patrimony were enormous, even greater dimension had the crimes against democracy itself.

The trial, which mobilised the nation and had live televised transmission, took place in nuclei. Jair Bolsonaro was part of the “crucial nucleus”, responsible for the planning and organisation of the coup acts (Supremo Tribunal Federal, Ação Penal 2668). According to the Attorney General's Office of the Republic (Ministério Público Federal, which brought the action), Jair Bolsonaro participated in the formulation and drafting of coup drafts and was fully aware of (approving it) the “Punhal Verde e Amarelo” plan, which intended to kill the elected president Lula, the elected vice-president Geraldo Alckmin and the STF minister Alexandre de Moraes.

Jair Bolsonaro was convicted of the crimes of leadership of a criminal organisation, attempt at the violent abolition of the democratic rule of law, coup d'état, damage against the patrimony of the Union and deterioration of listed patrimony.

The STF decided

TO CONVICT, by majority, the Minister Luiz Fux being outvoted, the defendant **Jair Messias Bolsonaro** for infractions of the articles: art. 359-L; art. 359-M; art. 163, sole paragraph, I, III and IV, all of the Penal Code; art. 2, *caput*, §§ 2, 3 and 4, II, of Law No. 12,850/2013 and art. 62, I, of Law No. 9,605/1998, in the form of art. 29, *caput*, and of article 69, *caput*, both likewise of the Penal Code. Totalling the custodial sentence, DEFINITELY, at **27 (twenty-seven) years and 3 (three) months, being 24 (twenty-four) years and 9 (nine) months of imprisonment (reclusão) and 2 (two) years and 6 (six) months of detention**, the initial closed regime being applied for the beginning of serving the sentence of the hereby convicted, in the form of art. 33, of the CP. Also sentenced to the pecuniary penalty of **124 (one hundred and twenty-four) day-fines**, which shall be calculated at the rate of 2 (two) minimum wages, in force at the time of the fact, duly adjusted, under the terms of article 49, § 1, of the CP (STF, AP 2668, s.d.)

7 CONCLUSIONS

Presidentialism is the regime of government unanimously adopted in Latin America, and it is possible to associate it with political instabilities and military dictatorships. In order to obtain success, the President needs to make an abundant distribution of positions and exchanges to the parties that make up the Legislature, allies and members of the opposition, in order to achieve some viability in the task of governing. This requires much skill from the President, who ideally will still keep within the dictates of democracy. When this limit is exceeded, then what is seen is the purchase of alliances, threats to destroy enemies, to destroy the free press, being able to reach coups.

If the president is merely unpopular, they will not be re-elected, having then been “punished” at the ballot box. There is no regular way to expel the president before the end of the mandate. Moreover, exceptionally there is *impeachment*, much more traumatic for the president and for the country. What cannot be accepted, and Brazil did not accept, is the practice of coup d'état.

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THE IMPLICIT FUNDAMENTAL RIGHT TO REPRODUCTIVE SELF-DETERMINATION: CONSTITUTIONAL FOUNDATIONS, HUMAN RIGHTS AND FEMINIST CONSTITUTIONALISM

O DIREITO FUNDAMENTAL IMPLÍCITO À AUTODETERMINAÇÃO REPRODUTIVA: FUNDAMENTOS CONSTITUCIONAIS, DIREITOS HUMANOS E CONSTITUCIONALISMO FEMINISTA

EL DERECHO FUNDAMENTAL IMPLÍCITO A LA AUTODETERMINACIÓN REPRODUTIVA: FUNDAMENTOS CONSTITUCIONALES, DERECHOS HUMANOS Y CONSTITUCIONALISMO FEMINISTA



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ABSTRACT

This article examines the theoretical and normative foundations of reproductive self-determination from the perspective of contemporary constitutionalism and feminist constitutionalism. It argues that reproductive decisions transcend the private sphere and constitute a matter of constitutional justice directly linked to human dignity, liberty, equality and health. The study analyses the international development of reproductive rights through the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), the International Conference on Population and Development (Cairo) and the Beijing Platform for Action. It also explores the contribution of feminist theories and Martha Nussbaum's capabilities approach to understanding reproductive autonomy as an essential condition for citizenship and substantive equality. Finally, it argues that reproductive self-determination should be recognized as an implicit fundamental right within the Brazilian constitutional order.

Keywords: Reproductive Self-determination. Fundamental Rights. Feminist Constitutionalism. Human Dignity. Bodily Autonomy.

RESUMO

O presente artigo analisa os fundamentos teóricos e normativos da autodeterminação reprodutiva a partir da perspectiva do constitucionalismo contemporâneo e do constitucionalismo feminista. Parte-se da compreensão de que as decisões relacionadas à reprodução ultrapassam a esfera privada e constituem questão de justiça constitucional diretamente vinculada à dignidade da pessoa humana, à liberdade, à igualdade e à saúde. O estudo examina a progressiva internacionalização dos direitos reprodutivos por meio da Convenção sobre a Eliminação de Todas as Formas de Discriminação contra a Mulher (CEDAW), da Conferência Internacional sobre População e Desenvolvimento do Cairo e da Plataforma de Ação de Pequim. Analisa-se, ainda, a contribuição das teorias feministas e da abordagem das capacidades desenvolvida por Martha Nussbaum para a compreensão da autonomia reprodutiva como condição indispensável para a efetivação da cidadania e da igualdade material. Sustenta-se que a autodeterminação reprodutiva pode ser reconhecida como direito fundamental implícito no ordenamento constitucional brasileiro, decorrente da articulação entre dignidade humana, liberdade, igualdade, privacidade, saúde e planejamento familiar.

Palavras-chave: Autodeterminação Reprodutiva. Direitos Fundamentais. Constitucionalismo Feminista. Dignidade Humana. Autonomia Corporal.

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RESUMEN

El presente artículo analiza los fundamentos teóricos y normativos de la autodeterminación reproductiva desde la perspectiva del constitucionalismo contemporáneo y del constitucionalismo feminista. Se parte de la comprensión de que las decisiones relacionadas con la reproducción sobrepasan la esfera privada y constituyen una cuestión de justicia constitucional directamente vinculada a la dignidad de la persona humana, a la libertad, a la igualdad y a la salud. El estudio examina la progresiva internacionalización de los derechos reproductivos a través de la Convención sobre la Eliminación de Todas las Formas de Discriminación contra la Mujer (CEDAW), de la Conferencia Internacional sobre Población y Desarrollo de El Cairo y de la Plataforma de Acción de Pekín. Se analiza, además, la contribución de las teorías feministas y del enfoque de las capacidades desarrollado por Martha Nussbaum para la comprensión de la autonomía reproductiva como condición indispensable para la efectivización de la ciudadanía y de la igualdad material. Se sostiene que la autodeterminación reproductiva puede ser reconocida como derecho fundamental implícito en el ordenamiento constitucional brasileño, derivado de la articulación entre dignidad humana, libertad, igualdad, privacidad, salud y planificación familiar.

Palabras clave: Autodeterminación Reproductiva. Derechos Fundamentales. Constitucionalismo Feminista. Dignidad Humana. Autonomía Corporal.

1 INTRODUCTION

The constitutionalisation of matters relating to reproduction represents one of the most significant transformations of contemporary constitutionalism. Themes historically treated as belonging to the private, moral or religious sphere have, in recent decades, come to form part of the core of constitutional debates concerning the protection of fundamental rights. This shift stems from the growing perception that decisions relating to sexuality, motherhood, contraception and family planning do not constitute merely individual choices devoid of public relevance, but directly influence the realisation of liberty, equality, health and human dignity.

For much of constitutional history, reproduction was understood as a dimension linked to family organisation and social morality, remaining relatively removed from the field of fundamental rights. The classic liberal distinction between the public and private spheres contributed to matters relating to the female body being treated as issues foreign to constitutional oversight, even when subjected to intense mechanisms of legal, religious and political regulation. The critique developed by feminist theories throughout the twentieth century revealed, however, that the apparent neutrality of this separation concealed structural power relations that profoundly conditioned women's reproductive experience.

From the second half of the twentieth century onwards, the strengthening of feminist movements and the progressive internationalisation of human rights contributed to transforming reproduction into a legitimate object of constitutional protection. International conferences, multilateral bodies and constitutional courts came to recognise that reproductive autonomy constitutes an indispensable condition for the realisation of gender equality and the full exercise of citizenship. In this context, the understanding was consolidated that the freedom to decide whether, when and under what circumstances to have children forms part of the set of existential choices constitutionally protected.

The recognition of reproductive rights, however, remains marked by intense legal, political and moral controversies. The protection of reproductive autonomy frequently comes into tension with arguments relating to the protection of potential life, public morality, religious convictions and the limits of state intervention over the human body. These disputes reveal that reproduction constitutes one of the most complex themes of contemporary constitutional theory, requiring the articulation of different fundamental rights and constitutional principles.

In light of this scenario, this article aims to analyse the constitutional foundations of reproductive self-determination, investigating whether it is possible to recognise it as an implicit fundamental right within the Brazilian constitutional order. To this end, it draws on the contribution of feminist constitutionalism and the theory of fundamental rights, examining the

internationalisation of reproductive rights, their relationship with human dignity and bodily autonomy, as well as the normative foundations that sustain their constitutional protection.

The hypothesis defended is that reproductive self-determination constitutes a fundamental right materially protected by the Constitution of the Republic of 1988, even though it is not expressly provided for in its formal catalogue of fundamental rights. Its protection derives from the systematic interpretation of the constitutional principles of human dignity, liberty, equality, privacy, health and family planning, as well as from the commitments assumed by the Brazilian State within the international framework of human rights.

2 REPRODUCTION AND CONSTITUTIONAL JUSTICE

For a long period, matters relating to reproduction were understood as issues belonging to the private sphere of human life. Pregnancy, motherhood, family planning and the raising of children were traditionally treated as themes linked to morality, religion and family organisation, remaining relatively removed from constitutional debate. This perception was influenced by the classic liberal separation between the public and private spheres, according to which constitutional law should concentrate on the organisation of the State and the protection of civil liberties, reserving a reduced space of legal intervention for family relations.

However, the apparent neutrality of this division proved insufficient to understand the power relations that historically shaped women's reproductive experience. As demonstrated by the feminist theories developed throughout the twentieth century, the location of reproduction in the private sphere did not mean the absence of state regulation. On the contrary, it allowed legal, political, religious and cultural mechanisms to operate intensely upon female bodies without the scrutiny proper to constitutional guarantees.

In this context, reproduction came to be understood not only as an individual or family experience, but as a phenomenon directly related to the distribution of power, resources and opportunities in a given society. The possibility of deciding whether, when and under what circumstances to have children significantly influences the insertion of women in educational, professional, economic and political spaces. Reproduction ceases to be perceived exclusively as a biological event and assumes its own constitutional relevance, insofar as it conditions the exercise of various fundamental rights.

Juliana Cesario Alvim Gomes observes that rights relating to sexuality and reproduction cannot be analysed solely from the perspective of abstract individual liberty. In examining the construction of sexual rights in contemporary constitutionalism, the author holds that autonomy can only be effectively exercised when accompanied by material and

symbolic conditions of equality, affirming that personal choices tend to become progressively more autonomous “as circumstances of equal access to material, symbolic and political goods can be achieved”. Such a formulation makes it possible to understand that reproduction constitutes not only a space of liberty, but also a matter related to distributive justice and to confronting structural inequalities.

The approximation between reproduction and constitutional justice finds its foundation in the observation that restrictions on reproductive autonomy disproportionately affect historically vulnerable groups. Poor, Black, Indigenous, migrant women or those residing in regions with precarious access to health services frequently face significantly greater obstacles to exercising free and informed reproductive choices. For this reason, the constitutional analysis of reproduction cannot be limited to the formal protection of individual liberty, but equally requires consideration of the concrete conditions that enable or prevent the effective exercise of that liberty.

3 REPRODUCTIVE RIGHTS FROM THE PERSPECTIVE OF FUNDAMENTAL RIGHTS

The progressive constitutionalisation of matters relating to sexuality and reproduction led to the recognition of reproductive rights as a legal category endowed with its own autonomy within the framework of human rights and fundamental rights. Although the expression only became consolidated in the last decades of the twentieth century, especially from the Cairo (1994) and Beijing (1995) Conferences onwards, its content finds its foundation in constitutional values historically associated with the protection of human dignity, individual liberty, equality and health.

The legal construction of reproductive rights did not occur in a linear fashion. For a long period, matters relating to reproduction were treated predominantly as issues of family, moral or religious interest, remaining relatively removed from the language of fundamental rights. From the second half of the twentieth century onwards, however, the strengthening of feminist movements, the internationalisation of human rights and the broadening of the recognition of women's autonomy contributed to shifting reproduction into the field of constitutional citizenship.

In this context, reproductive rights came to be understood as the set of prerogatives that ensure individuals the possibility of deciding freely and responsibly on matters relating to reproduction, including the decision whether or not to have children, the timing of having them, the spacing between pregnancies and access to the means necessary to bring about such choices. This conception departs from restrictive interpretations that reduce reproductive rights to the protection of motherhood or the regulation of birth rates, recognising

their intimate connection with personal autonomy and the freedom of development of the personality.

The constitutional relevance of these rights derives precisely from their multifaceted nature. Reproductive rights are not exhausted in a single normative dimension, but result from the convergence of different fundamental rights that, together, ensure the protection of reproductive autonomy. Liberty, equality, human dignity, health, privacy, physical integrity and family planning constitute some of the legal bases that sustain their recognition in contemporary constitutionalism.

The understanding of reproductive rights as a complex legal category finds support in the process of internationalisation of human rights that took place throughout the second half of the twentieth century. In this sense, Flávia Piovesan highlights that the World Conference on Human Rights held in Vienna in 1993 consolidated the understanding according to which all human rights are universal, indivisible, interdependent and interrelated. According to the Vienna Declaration and Programme of Action:

“All human rights are universal, indivisible, interdependent and interrelated. The international community must treat human rights globally in a fair and equal manner, on the same footing, and with the same emphasis.”²

The importance of this formulation for reproductive rights is evident. Decisions relating to reproduction do not exclusively involve the sphere of individual liberties, nor can they be understood solely from the perspective of social rights. On the contrary, the protection of reproductive autonomy requires the simultaneous operation of different fundamental rights, including liberty, equality, health, privacy and human dignity. Reproductive rights thus constitute a concrete expression of the indivisibility of human rights.

This understanding is reinforced by Piovesan herself when she holds that the conception according to which social rights would not constitute authentic fundamental rights has been superseded. The protection of human dignity requires the recognition of the indivisibility between civil, political, economic, social and cultural rights, rejecting interpretations that attribute a hierarchy among these different normative categories.³

From this perspective, reproductive rights prove particularly illustrative of the interdependence of fundamental rights, since their realisation simultaneously presupposes protection against arbitrary interference and access to positive provisions indispensable to the exercise of reproductive autonomy.

² PIOVESAN, Flávia. *Human Rights and International Constitutional Law*. 21st ed. São Paulo: Saraiva, 2023, p. 236.

³ PIOVESAN, Flávia. *Human Rights and International Constitutional Law*. 21st ed. São Paulo: Saraiva, 2023, p. 238.

Among the foundations that make up the normative core of reproductive rights, liberty stands out initially. Reproductive liberty ensures individuals a space of self-determination to decide on matters relating to sexuality, motherhood, fatherhood and the constitution of the family. It is a specific manifestation of personal autonomy, directly linked to the free development of the personality.

However, reproductive liberty cannot be understood in an abstract manner or detached from the concrete conditions under which choices are made. As Juliana Cesario Alvim Gomes observes, one of the central questions of sexual rights consists precisely in investigating:

“To what extent should sexual rights be defined on the basis of the individual's autonomy to make choices about their own life and sexuality? To what extent do power structures limit and constrain those choices?”⁴

The author demonstrates that choices relating to sexuality and reproduction are conditioned by economic, social, cultural and institutional factors that directly influence individuals' decision-making capacity. Consequently, the protection of reproductive rights cannot be reduced to the mere absence of state intervention.

This observation leads to the second foundation of reproductive rights: equality. The effectiveness of reproductive autonomy depends on the existence of conditions that enable people to exercise their choices in an autonomous and meaningful way. In societies marked by profound inequalities of gender, race and social class, formal liberty frequently proves insufficient to ensure real autonomy.

Equality, therefore, does not act merely as a principle of prohibition of discrimination, but also as a foundation for the adoption of measures capable of removing obstacles that hinder the effective exercise of reproductive liberty. Autonomy can only be considered genuine when accompanied by material conditions that make its realisation possible.

Health constitutes another indispensable component of reproductive rights. The International Conference on Population and Development held in Cairo recognised that reproductive health involves a state of complete physical, mental and social well-being in all aspects relating to the reproductive system. It is not merely the absence of illness, but the guarantee of conditions that enable individuals to exercise control over their reproductive life.

The protection of reproductive health requires access to adequate medical services, reliable scientific information, safe contraceptive methods and qualified professional monitoring. Without these elements, reproductive liberty remains limited and incapable of producing concrete results in people's lives.

⁴ GOMES, Juliana Cesario Alvim. *Sexual rights and their legal foundation*. Rio de Janeiro: Lumen Juris, 2022, p. 41.

Privacy also plays a relevant role in the protection of reproductive rights. Decisions relating to reproduction belong to the most intimate core of the personality, which is why they must be protected against arbitrary interference by the State or by third parties. The protection of privacy ensures the space of autonomy necessary for individuals to formulate existential choices compatible with their convictions and life projects.

The interaction between liberty, equality, health, privacy and human dignity reveals that reproductive rights constitute a complex legal category, whose realisation depends on the simultaneous operation of multiple fundamental rights. Reproductive autonomy emerges precisely from the convergence of these different constitutional guarantees.

The understanding of reproductive rights as an expression of the indivisibility of fundamental rights makes it possible to overcome reductionist views that treat them exclusively as a matter of individual liberty or exclusively as public health policy. It is, in reality, a multifaceted constitutional category that simultaneously involves self-determination, material equality, protection of health and recognition of human dignity.

For this reason, the analysis of reproductive rights leads inevitably to the examination of the normative foundations that confer unity upon these different dimensions. Among these foundations, human dignity and bodily autonomy stand out in particular, which will be analysed below as constitutional bases of reproductive self-determination.

4 HUMAN DIGNITY AND BODILY AUTONOMY AS NORMATIVE FOUNDATIONS OF REPRODUCTIVE SELF-DETERMINATION

The constitutional protection of reproductive self-determination finds its principal normative foundations in human dignity and bodily autonomy. Although reproductive rights are frequently analysed on the basis of specific guarantees relating to health, privacy or family planning, their deeper justification derives from the recognition that each individual possesses intrinsic value and must be treated as a subject capable of autonomously conducting their own existence. In this sense, reproductive self-determination does not constitute a mere projection of individual interests relating to sexuality or motherhood, but a direct expression of human dignity as a structuring principle of contemporary constitutionalism.

The centrality of human dignity within the constitutional system results from the progressive affirmation of the person as the ultimate purpose of the legal order. More than a specific legal principle, dignity acts as the axiological foundation of fundamental rights, guiding constitutional interpretation and establishing limits on the exercise of state power. As Ingo Wolfgang Sarlet observes:

“We understand human dignity to be the intrinsic and distinctive quality recognised in each human being that makes them deserving of the same respect and consideration on the part of the State and the community, entailing, in this sense, a complex of fundamental rights and duties that protect the person both against any and all acts of a degrading and inhuman nature and that guarantee them the minimum existential conditions for a healthy life, in addition to enabling and promoting their active and co-responsible participation in the destinies of their own existence and of life in communion with other human beings.”⁵

The formulation proposed by Sarlet reveals that dignity is not limited to protection against degrading treatment or the guarantee of minimum conditions of survival. Its contemporary dimension equally encompasses the protection of individual autonomy and the capacity of each person to participate actively in the construction of their own existential trajectory. Choices relating to sexuality, motherhood, the constitution of the family and reproduction are inserted precisely within this set of fundamental decisions that give meaning to the free development of the personality.

From this perspective, reproduction ceases to be understood exclusively as a biological phenomenon or as a matter of family interest and assumes a dimension directly related to human dignity. The imposition of reproductive decisions by third parties — whether the State, religious institutions, health professionals or members of the family itself — represents a potential violation of individual autonomy, insofar as it transfers to external agents choices that belong to the most intimate core of the personality.

The connection between human dignity and reproductive self-determination also finds relevant development in contemporary feminist doctrine. Laura Ronchetti holds that women's autonomy must be understood as a constitutionally protected sphere of sexual and reproductive self-determination, indispensable for the realisation of substantive equality. According to the author:

“Only a legal perspective based on the personal autonomy of women — understood as a sphere of sexual and reproductive self-determination constitutionally guaranteed and intimately linked to the objective of self-realisation — can ensure the equal social dignity of all persons in our legal order, regardless of sex or gender.”⁶

The reflection developed by Ronchetti makes it possible to understand that reproductive self-determination does not constitute a mere manifestation of negative liberty. It is a legal position whose protection is indispensable for women to be recognised as full subjects of rights, capable of autonomously formulating and realising their life projects. Reproductive autonomy ceases to be perceived merely as an individual faculty and assumes

⁵ SARLET, Ingo Wolfgang. *Human dignity and fundamental rights in the Federal Constitution of 1988*. 13th ed. Porto Alegre: Livraria do Advogado, 2022, p. 73.

⁶ RONCHETTI, Laura. *L'autodeterminazione riproduttiva delle donne*. Napoli: Editoriale Scientifica, 2018, p. 112.

a structural dimension related to gender equality and to the very realisation of the democratic ideal.

The understanding of human dignity as a foundation of reproductive autonomy also finds important support in the capabilities theory developed by Martha C. Nussbaum. Departing from purely formal conceptions of liberty, the author holds that dignity requires the guarantee of real opportunities so that individuals may exercise fundamental choices relating to their own existence.

Among the central capabilities necessary for human flourishing, Nussbaum expressly includes bodily integrity, defined in the following terms:

“Bodily integrity. Being able to move freely from place to place; having one's bodily boundaries treated as sovereign, i.e. being able to be secure against assault, including sexual assault, child sexual abuse, and domestic violence; having opportunities for sexual satisfaction and for choice in matters of reproduction.”⁷

The relevance of this formulation for the constitutional protection of reproductive self-determination is evident. The capacity to make choices relating to reproduction does not appear as a secondary interest or a mere individual preference. On the contrary, it forms part of the set of conditions indispensable for a dignified life and for the full development of human potential.

The capabilities theory makes it possible to overcome excessively individualistic interpretations of reproductive liberty. For Nussbaum, it is not enough to formally ensure the right to choose. It is necessary to guarantee the material conditions that make that choice effectively possible. Liberty is only realised when accompanied by the means necessary for its realisation.

The author emphasises this relationship when she affirms that:

“The emphasis on capabilities as social goals is closely linked to an emphasis on human equality, in the sense that discrimination on the basis of race, religion, sex, nationality, caste, or ethnicity is taken to be, in itself, a failure in the capability of affiliation, a type of indignity or humiliation.”⁸

This understanding is of special relevance for reproductive rights. Historical experience demonstrates that women face not only formal legal restrictions on reproductive autonomy. Economic, cultural and institutional obstacles frequently limit their concrete capacity to exercise control over their own bodies. The constitutional protection of

⁷ NUSSBAUM, Martha C. *Women and Human Development: The Capabilities Approach*. Cambridge: Cambridge University Press, 2000, p. 78.

⁸ NUSSBAUM, Martha C. *Women and Human Development: The Capabilities Approach*. Cambridge: Cambridge University Press, 2000, p. 82.

reproductive self-determination therefore requires not only the elimination of arbitrary interventions, but also the adoption of measures capable of removing structural barriers that prevent the effective exercise of liberty.

At this point, the contribution of Juliana Cesario Alvim Gomes proves particularly relevant. In developing an integrated approach between liberty and equality for the protection of sexual rights, the author warns that autonomy cannot be conceived as an abstract attribute, exercised independently of the concrete conditions in which individuals live. In her words:

“Liberty read in the light of equality would require equal conditions for the exercise of the freedom to invent and choose the way of living one’s own life, avoiding the abuse of economic power and the idealisation of the individual decision as being completely autonomous.”⁹

The formulation proposed by Gomes makes clear that bodily autonomy cannot be reduced to the simple absence of state coercion. Decisions relating to sexuality, motherhood and reproduction are frequently influenced by economic, social and cultural factors that concretely condition the possibilities of choice available to women.

Bodily autonomy thus assumes a dual dimension. In a negative sense, it protects against undue interference over the body and the reproductive capacity. In a positive sense, it requires the creation of conditions capable of ensuring the effective exercise of reproductive liberty. This dual function proves particularly important when one considers that the female body has historically constituted a privileged object of legal, political and moral control.

Over the centuries, legal norms, religious discourses and institutional practices were used to regulate female sexuality and determine socially acceptable standards of motherhood. Reproduction was frequently presented as the natural destiny of the female condition, converting reproductive capacity into an instrument for legitimising structures of inequality and dependence. The constitutional protection of bodily autonomy represents, in this context, an important mechanism for overcoming these historical forms of subordination.

The connection between human dignity, bodily autonomy and reproductive self-determination makes it possible to understand that decisions relating to reproduction form part of the most protected core of the personality. The choice whether or not to have children, to define the timing of motherhood, to use contraceptive methods or to resort to assisted reproduction techniques involves central aspects of the identity, liberty and existential projects of individuals. For this reason, intervention over the reproductive sphere does not affect only private interests, but has direct repercussions on the capacity for self-determination that the Constitution seeks to ensure for all persons.

⁹ GOMES, Juliana Cesario Alvim. *Sexual rights and their legal foundation*. Rio de Janeiro: Lumen Juris, 2022, p. 214.

Reproductive self-determination thus emerges as a concrete projection of human dignity and bodily autonomy. Its recognition ensures women the condition of subjects capable of formulating and realising their own life projects, rejecting conceptions that subordinate their choices to collective, moral or institutional interests defined by third parties. The protection of reproductive autonomy is therefore not limited to the guarantee of individual liberty, but forms part of the very constitutional commitment to substantive equality, democratic citizenship and the full development of the personality.

5 REPRODUCTIVE SELF-DETERMINATION AS AN IMPLICIT FUNDAMENTAL RIGHT

The constitutional protection of reproductive self-determination does not depend on the existence of an express provision in the constitutional text. Contemporary constitutionalism has consolidated the understanding that fundamental rights are not exhausted in the catalogue formally provided for by constitutions, admitting the recognition of materially fundamental rights extracted from the principles, values and guarantees that structure the constitutional order. The Constitution comes to be understood not as a closed system of previously enumerated rights, but as an open order of protection of the human person, capable of encompassing new demands arising from social, political and cultural transformations.

This understanding assumes special relevance in the field of reproductive rights. Although the Constitution of the Republic of 1988 does not expressly mention reproductive self-determination, several of its provisions offer normative support for the recognition of a constitutionally protected sphere of autonomy relating to reproduction. Human dignity, liberty, equality, privacy, health and family planning constitute foundations that, interpreted systematically, make it possible to identify the existence of a fundamental right aimed at the protection of individuals' reproductive choices.

The debate concerning reproductive self-determination as an implicit fundamental right is therefore part of a broader discussion on the material openness of the catalogue of fundamental rights and on the capacity of the Constitution to respond to new forms of vulnerability and exclusion. It is a matter of investigating whether the protection of reproduction can be understood as a necessary consequence of the constitutional principles that ensure liberty, equality and human dignity, even in the absence of a specific textual provision.

The possibility of recognising fundamental rights not expressly provided for in the constitutional text finds its foundation in the very normative structure of the Constitution of 1988. Alongside the formal catalogue of fundamental rights and guarantees, the Brazilian

constituent adopted a clause of material openness intended to allow the incorporation of new rights arising from constitutional principles and international human rights treaties. In this context, Article 5, § 2, of the Constitution establishes that the rights and guarantees expressed in the constitutional text do not exclude others arising from the regime and principles adopted by it or from the international treaties to which the Federative Republic of Brazil is a party.

Brazilian constitutional doctrine widely recognises that this provision enshrines an open system of fundamental rights. As Ingo Wolfgang Sarlet observes, the Constitution of 1988 admits the existence of materially fundamental rights that, although not expressly provided for in its catalogue, derive directly from the values and structuring principles of the constitutional order. The fundamentality of a given right does not depend exclusively on its topographical location in the constitutional text, but also on its content and its close connection to the protection of human dignity and to the free development of the personality.¹⁰

The material openness of the constitutional catalogue proves particularly important in the face of the social transformations that characterise contemporary democracies. The evolution of social relations frequently produces legal situations that were not expressly contemplated by the original constituent, but which require constitutional protection by reason of their connection with the fundamental values of the democratic order. Constitutional interpretation comes to play, in this context, a decisive role in the identification and protection of legal positions indispensable to the realisation of liberty, equality and human dignity.

The identification of an implicit fundamental right requires the demonstration of its connection to the structuring principles of the Constitution. It is not a matter of recognising new rights in an arbitrary manner, but of verifying whether a given legal position constitutes a necessary projection of the values that shape the Democratic State governed by the rule of law. From this perspective, reproductive self-determination presents an unequivocally materially fundamental nature.

Decisions relating to reproduction directly affect individuals' capacity to formulate and realise their own life projects, influencing existential choices relating to sexuality, the constitution of the family, motherhood, fatherhood and the development of the personality. It is a decision-making sphere that bears upon central aspects of the human condition and which, for this reason, cannot remain outside constitutional protection.

The connection between reproductive self-determination and human dignity derives from the recognition that each person must be treated as a moral subject capable of making

¹⁰ SARLET, Ingo Wolfgang. *The effectiveness of fundamental rights*. 14th ed. Porto Alegre: Livraria do Advogado, 2022, p. 88-91.

fundamental choices about their own existence. The imposition of reproductive decisions by the State or by third parties directly compromises this condition of autonomy, transforming individuals into instruments of purposes that are external to them. The protection of reproductive self-determination therefore constitutes a requirement inherent in the principle of human dignity, insofar as it ensures individuals control over an essential dimension of their identity and their existential projects.

The understanding of reproduction as a protected sphere of individual autonomy finds important support in the constitutional theory developed by Ronald Dworkin. In reflecting on decisions relating to birth, family and reproduction, the author holds that certain choices belong to the core of individual moral responsibility and must be reserved primarily to the individuals themselves. According to Dworkin, existential decisions relating to the way in which each person intends to conduct their own life constitute manifestations of the ethical liberty indispensable to human dignity.¹¹

Dworkin's contribution proves especially relevant to the theme of reproductive self-determination because it makes it possible to understand that decisions relating to motherhood and reproduction do not involve only personal preferences. They concern the definition of fundamental values, the construction of individual identity and the formulation of existential projects that cannot legitimately be substituted by the will of the State or by majority moral conceptions. Reproduction thus forms part of the set of choices that belong to the domain of constitutionally protected individual autonomy.

However, reproductive self-determination does not derive exclusively from individual liberty. Its constitutional protection equally requires consideration of the concrete conditions under which choices are made. In this sense, Juliana Cesario Alvim Gomes holds that the effectiveness of sexual and reproductive rights depends on the articulation between liberty and equality, rejecting conceptions that privilege only one of these dimensions.¹²

Liberty ensures the space of individual decision; equality provides the conditions necessary for that decision to be exercised in an autonomous, informed and meaningful way. Reproductive self-determination therefore presents itself as a legal position whose fundamentality results precisely from the interaction between these two constitutional categories. The protection of reproduction is not limited to the prohibition of arbitrary interference, but equally requires the adoption of measures intended to remove structural obstacles that hinder the exercise of autonomy.

¹¹ DWORKIN, Ronald. *Life's Dominion: An Argument About Abortion, Euthanasia, and Individual Freedom*. New York: Vintage Books, 1994, p. 154-167.

¹² GOMES, Juliana Cesario Alvim. *Sexual rights and their legal foundation*. Rio de Janeiro: Lumen Juris, 2022, p. 213-215.

The connection between reproductive self-determination, liberty and equality finds important support in the Brazilian constitutional text itself. In regulating rights relating to the family and reproduction, the Constitution of 1988 enshrined family planning as a fundamental right linked to human dignity and responsible parenthood. Article 226, § 7, establishes that:

“Founded on the principles of human dignity and responsible parenthood, family planning is the free decision of the couple, it being incumbent upon the State to provide educational and scientific resources for the exercise of this right, any coercive form on the part of official or private institutions being prohibited.”¹³

The constitutional provision of family planning is of special relevance for the construction of reproductive self-determination as an implicit fundamental right. Although the provision does not expressly employ this terminology, it recognises the existence of a sphere of decision relating to reproduction protected against coercive interference and directly linked to human dignity.

More than that, the constituent did not limit itself to ensuring negative liberty in the face of possible state interventions. It equally attributed to the State the duty to provide educational and scientific resources capable of enabling the effective exercise of this right. The constitutional norm therefore makes clear the simultaneous presence of the negative and positive dimensions of reproductive autonomy, reinforcing the understanding that reproduction forms part of the set of constitutionally protected liberties.

The constitutional reference to free reproductive decision demonstrates that the Constitution does not conceive of reproduction as a matter subject exclusively to state determination or to the imposition of uniform moral standards. On the contrary, it attributes to individuals a space of autonomy to define fundamental aspects of their family and reproductive life, recognising that such choices form part of the scope of constitutional liberties.

From this perspective, family planning may be understood as one of the most relevant normative manifestations of reproductive self-determination in the Constitution of 1988. From the articulation between human dignity, liberty, equality, health, privacy and family planning, it becomes possible to identify the existence of a fundamental legal position aimed at the protection of individuals' reproductive choices.

Reproductive self-determination does not, therefore, arise as a right artificially created by constitutional interpretation. On the contrary, it presents itself as a logical and systematic consequence of the principles and guarantees that structure the Brazilian constitutional order. Its protection derives from the need to ensure that each person can exercise control over

¹³ BRAZIL. Constitution of the Federative Republic of Brazil of 1988. Art. 226, § 7.

fundamental aspects of their own existence, formulating life projects compatible with their convictions, values and aspirations.

In this way, reproductive self-determination must be recognised as an implicit fundamental right within the Brazilian constitutional order. Its material fundamentality derives from its intimate connection to human dignity, individual liberty, substantive equality, privacy, health and family planning. In a constitutional order founded on the centrality of the human person, the protection of the capacity to decide on one's own reproduction constitutes a requirement inherent in the democratic commitment to liberty, equality and justice.

6 FINAL CONSIDERATIONS

The constitutionalisation of matters relating to reproduction constitutes one of the most relevant transformations of contemporary constitutionalism. Over the last decades, themes historically relegated to the private sphere have come to be progressively incorporated into constitutional debate, revealing that decisions relating to sexuality, motherhood, family planning and reproductive capacity have a profound connection with the realisation of fundamental rights and with the very realisation of democratic citizenship.

The course developed in this study made it possible to demonstrate that reproduction cannot be understood exclusively as a biological phenomenon, a private experience or a matter of individual morality. Reproductive choices directly influence the educational, professional, economic and political opportunities of people, especially of women, assuming their own constitutional relevance. For this reason, reproductive autonomy must be analysed as a matter of constitutional justice, directly linked to the distribution of resources, opportunities and capabilities indispensable to the exercise of liberty and equality.

The internationalisation of human rights played a decisive role in this process. The Convention on the Elimination of All Forms of Discrimination against Women, the International Conference on Population and Development held in Cairo and the Beijing Platform for Action contributed to consolidating the understanding that reproductive rights form part of the universal legal heritage of human rights. The freedom to decide whether, when and under what circumstances to have children came to be recognised as an indispensable element for the realisation of human dignity, gender equality and democratic participation.

The analysis of reproductive rights from the perspective of fundamental rights made clear their necessarily multidimensional character. The protection of reproductive autonomy does not derive from a single isolated constitutional guarantee, but from the convergence between liberty, equality, privacy, health, bodily integrity and human dignity. Reproductive rights constitute a paradigmatic expression of the indivisibility and interdependence of

fundamental rights, requiring simultaneously protection against arbitrary interference and access to the material conditions necessary for the effective exercise of autonomy.

In this context, human dignity and bodily autonomy prove to be the principal normative foundations of reproductive self-determination. The constitutional protection of reproduction is not limited to the formal guarantee of freedom of choice, but presupposes the recognition that each individual possesses intrinsic value and moral capacity to autonomously conduct their own existence. Decisions relating to sexuality, motherhood and the constitution of the family form part of the most protected core of the human personality, which is why they cannot legitimately be subordinated to external interests defined by third parties.

The research also demonstrated that reproductive self-determination can be recognised as an implicit fundamental right within the Brazilian constitutional order. Although the Constitution of the Republic of 1988 does not expressly employ this terminology, the systematic interpretation of its principles and guarantees makes it possible to identify a constitutionally protected sphere of autonomy relating to reproduction. Human dignity, liberty, equality, privacy, health and family planning constitute normative foundations sufficient to sustain the existence of a fundamental legal position aimed at the protection of individuals' reproductive choices.

The clause of material openness provided for in Article 5, § 2, of the Constitution reinforces this conclusion by admitting the recognition of materially fundamental rights not expressly provided for in its formal catalogue. Reproductive self-determination presents an unequivocal material fundamentality, insofar as it protects existential choices directly related to the free development of the personality and to the realisation of human dignity.

It is concluded, therefore, that reproductive self-determination constitutes an implicit fundamental right within Brazilian constitutionalism, whose protection derives from the very axiological logic of the Constitution of 1988. The recognition of this legal position does not represent an artificial creation of constitutional interpretation, but a necessary consequence of the democratic commitment to liberty, substantive equality and human dignity. In pluralist societies committed to the protection of fundamental rights, ensuring people control over their own reproductive decisions constitutes an indispensable condition for the full realisation of citizenship and for the realisation of the constitutional project inaugurated by the Constitution of the Republic.

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EVALUATION OF POSTGRADUATE PROGRAMS IN THE NATIONAL POSTGRADUATE SYSTEM IN MEXICO: GUIDE TO GOOD PRACTICES FOR NON-SCHOOL-BASED POSTGRADUATE PROGRAMS

AVALIAÇÃO DE PROGRAMAS DE PÓS-GRADUAÇÃO NO SISTEMA NACIONAL DE PÓS-GRADUAÇÃO DO MÉXICO: GUIA DE BOAS PRÁTICAS PARA PROGRAMAS DE PÓS-GRADUAÇÃO NÃO VINCULADOS A UNIVERSIDADES DE ENSINO SUPERIOR

LA VALORACIÓN DE LOS PROGRAMAS DE POSGRADOS EN EL SISTEMA NACIONAL DE POSGRADOS EN MÉXICO: GUÍA DE BUENAS PRÁCTICAS PARA POSGRADOS NO ESCOLARIZADOS



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ABSTRACT

Postgraduate programs are subject to periodic evaluations to maintain their standing within Mexico's National Postgraduate System (SNP). This article presents a management methodology for non-classroom postgraduate programs, aimed at strengthening the permanence of the Master's Program in Emerging Information Technologies (MTIE) within the SNP of the Secretariat of Science, Humanities, Technology, and Innovation (SECIHTI). The objective is to guide programs toward favorable evaluations across five required dimensions: (1) academic program capacities; (2) commitment to student development; (3) curriculum relevance; (4) commitment to inclusion and substantive equality; and (5) commitment to society. The study is documentary in nature and organizes graduate program management into structured stages. The result is a replicable guide of good practices for non-classroom postgraduate programs in Mexican higher education institutions (HEIs). The study concludes that governmental regulatory changes do not invalidate the guide but require its continuous updating.

Keywords: Education. Postgraduate. Virtual. Best Practice. Public Policies.

RESUMO

Os programas de pós-graduação estão sujeitos à avaliação para sua permanência no Sistema Nacional de Pós-Graduação (SNP), este artigo apresenta uma metodologia de

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gestão para programas de pós-graduação não tradicionais, bem como uma estratégia para fortalecer a permanência do Programa de Mestrado em Tecnologias Emergentes da Informação (MTIE) no SNP da Secretaria de Ciência, Humanidades, Tecnologia e Inovação (SECIHTI). O objetivo é alcançar uma avaliação satisfatória em cinco dimensões: (1) competências acadêmicas do programa, (2) compromisso com a formação dos alunos, (3) relevância do currículo, (4) compromisso com a inclusão e a igualdade substancial e (5) compromisso com a sociedade. Para tanto, o programa é classificado por etapas ou processos na gestão de um programa de mestrado. Isso resulta em um guia de boas práticas para programas de pós-graduação não tradicionais em Instituições de Ensino Superior (IES) mexicanas, levando à conclusão de que as mudanças governamentais não alteram esse guia; pelo contrário, o aprimoram.

Palavras-chave: Educação. Posgrado. Virtual. Melhores Práticas. Políticas Públicas.

RESUMEN

Los programas de posgrado están sujetos a evaluación para su permanencia en el Sistema Nacional de Posgrados (SNP). Este artículo presenta una metodología de gestión para programas de posgrados no escolarizados, así como para fortalecer la permanencia del programa de maestría en Tecnologías de Información Emergentes (MTIE) en el Sistema Nacional de Posgrados de la Secretaría de Ciencia, Humanidad, Tecnología e Innovación (SECIHTI). Teniendo como finalidad la valoración aceptable en las cinco dimensiones: (1) capacidades académicas de programa, (2) compromiso con la formación de las y los estudiantes, (3) pertinencia del programa de estudios, (4) compromiso con la inclusión y la igualdad sustantiva, y (5) compromiso con la sociedad. Para ello se procede a clasificar por etapas o procesos en la gestión de un programa de maestría. De esta manera, da como resultado una guía de buenas prácticas para posgrados no escolarizados en Instituciones de Educación Superior (IES) mexicanas, lo que permite concluir que los cambios gubernamentales no alteran dicha guía sino al contrario.

Palabras clave: Educación. Posgrado. Virtual. Buenas Práticas. Políticas Públicas.

1 INTRODUCTION

Since the publication of the Guidelines of the National Postgraduate System of the Secretariat of Science, Humanities, Technology, and Innovation (SECIHTI) in the Official Gazette of the Federation on 21 October 2025 (SECIHTI, 2025), the postgraduate programs of universities, higher education institutions (HEIs), and research centres in Mexico have sought recognition of their programs in order to obtain scholarships and complementary support for people undertaking postgraduate studies at an HEI.

For more than a decade, Mexican universities have faced a significant challenge in integrating their postgraduate programs into the National Postgraduate Quality Program (PNPC), which is being replaced by the National Postgraduate System (SNP). Studies by Becerra Romero (2017) demonstrate the low accreditation rate of postgraduate programs in the state of Nayarit. Similarly, another study by Cajigal-Molina and Hernández-Marín (2020) on the current situation of postgraduate programs in the state of Campeche confirms this reality, noting that only two higher education institutions (HEIs) received quality accreditation for their programs.

However, the Statistical Yearbook of Higher Education – Postgraduate (ANUIES, 2025) for the 2024-2025 academic year, adding to the research the variables of student population (enrolled, new entrants, and graduates), federal entity, type of institution (state public universities, federal public universities, and technological universities), level of study (master's degree), and mode of study (non-classroom), reflects the reality of students enrolled in non-classroom postgraduate programs at the master's level. It is possible to highlight, in the Southeast of Mexico, an average of 15 students in the states of Campeche, Chiapas, and Tabasco, compared with an average of 43 students in the states of the central region of the country (State of Mexico, Puebla, and Morelos).

It is worth noting that both studies conclude that higher education institutions (HEIs) play an important role in high-level professional training due to the diversity of their postgraduate programs, with a differentiating factor being the increase in the percentage of programs accredited in the National Postgraduate System (SNP), as well as the creation of spaces for research and postgraduate programs oriented towards social commitment, research for solving priority problems, and improvement of academic consolidation indicators.

Considering that, in order to obtain recognition of postgraduate programs within the framework of the National Postgraduate System (SNP), the minimum conditions of a postgraduate program must be ensured across five dimensions: (1) academic capacities of the program, (2) commitment to student development, (3) relevance of the program of study, (4) commitment to inclusion and substantive equality, and (5) commitment to society

(SECIHTI, 2025). Therefore, at present, a total of 2,535 postgraduate programs, including specialisations, master's degrees, and doctorates, are accredited in the SNP throughout the country (SECIHTI, 2025).

Postgraduate programs in Mexico are classified into two categories: specialised programs, oriented towards industry, and those accredited by SECIHTI (Secretariat of Science, Technology, and Innovation), which focus on research and technological development (professional programs). Two modes of teaching are also recognised: classroom-based and distance learning (hybrid or blended teaching) (DOF, 2025). In this context, the Master's Program in Emerging Information Technologies (MTIE), since its creation, has adhered to the parameters established by the National Postgraduate Quality Program (PNPC) since 2019. However, due to governmental changes and the continuous improvement of the program's mechanisms, the MTIE was re-accredited by the SNP (National System of Postgraduate Programs) in the 2025 call (SECIHTI, 2025).

Along these same lines, public universities, by offering more postgraduate programs within the framework of the National System of Researchers (SNP), guarantee social recognition and access to national scholarships for the students of these programs, even in the face of the challenges of achieving financial balance in the operation of a postgraduate program at a higher education institution (HEI).

Given the characteristics inherent to postgraduate programs, these arise from the needs of the region, of disciplinary groups or academic bodies, and of researchers of the National System of Researchers (SNII), and form an Academic Core (NAB) that will support the postgraduate program in question. Nevertheless, management and organisation mechanisms are essential for the operation of a postgraduate program in order to obtain accreditation within the framework of the SNP.

Therefore, this article presents a guide of good practices to maintain the operational efficiency and continuous improvement of a postgraduate program, as well as its permanence in the SNP in Mexico.

2 THEORETICAL BACKGROUND

At the national level, Villalobos-López (2024) presents a “historical overview of postgraduate studies in Mexico and online doctorates”, from 2010 to 2022, highlighting that in the last academic year of 2021-2022, 183,868 postgraduate students enrolled in non-classroom programs, of whom 13% enrolled in public higher education institutions and the remainder in private higher education institutions; demonstrating that private higher education

institutions were not accredited in the national postgraduate quality program, although he justifies that private higher education institutions are the most prestigious in the country.

Although there are other studies, such as that of Esquivel-Becerril, Reyes-García, and Reyes García (2018), which presents “postgraduate studies and the current situation in Mexico”, highlighting national scholarships as the main means of access to quality postgraduate programs, García-García (2009) emphasises the importance of analysing institutional dynamics, allowing the recognition of academic, administrative, and organisational capacities to achieve better quality indicators. Similarly, Reyes-Mojarras (2006) presents the challenges faced by postgraduate programs in Mexico in the field of Law, offering some considerations that address the current state of postgraduate studies in Mexico.

Another work worth mentioning is that of Álvarez Mendiola and Carrillo Valdez (2025), which presents “Postgraduate studies in Mexico: Recent trends in their expansion and diversification”. It demonstrates significant growth in postgraduate programs at private higher education institutions (HEIs) compared with public HEIs, classifying non-classroom postgraduate programs, and mentions the lack of clear guidelines or procedures to strengthen postgraduate accreditation criteria.

At the international level, there are also studies on the factors that assess academic quality in postgraduate programs, as mentioned by Soto-Grant and Castro-Garro (2024). They highlight that the quality of a postgraduate program is not limited to what happens within classrooms or laboratories, but depends on two macro-processes of external management: proactive engagement with the community/industry and systematic monitoring of the impact of graduates. They conclude that specific administrative indicators should be developed to measure integration into the labour market and the social contribution of graduates, adapting to local, regional, and national economic realities, rather than blindly replicating accreditation models from developed countries.

Along these same lines, Valdés-Montecinos, Correa-Castillo, Briceño-Toledo y Suárez-Amaya, (2021) present a study on self-assessment models and best practices in non-classroom postgraduate programs, demonstrating that administrative management in virtual environments requires a transformation of staff to become mediators of learning and facilitators of digital procedures, highlighting as a key practice the articulation of learning management systems with academic and financial control systems, allowing postgraduate students to manage their activities, thesis supervision, and payments autonomously and asynchronously, in order to increase student satisfaction and the efficiency of academic

management processes, with the intention of accrediting their management processes nationally or internationally through the ISO 9001:2015 standard.

Finally, the organisational structure and comprehensive management guidelines for postgraduate programs are part of the administrative formality of a program, since they not only establish internal rules but also ensure that the program meets the standards of quality and transparency before accreditation bodies. A practical example of multi-campus governance is Universidad Santo Tomás (2019), which presents a detailed guide for essential administrative processes, such as the control and registration of academic records, the formal appointment of thesis supervisors and examiners through standardised committee minutes, and the mandatory alignment of curricula with current institutional research lines, among others. This aims to mitigate administrative informality and ensure the traceability of documents before any governmental entity.

3 METHODOLOGY

This study is documentary and descriptive in nature. It is based on the systematic review and analysis of the SNP Guidelines (DOF, 2025), institutional regulations, SECIHTI evaluation criteria, and relevant academic literature, with the aim of constructing a guide of good practices focused on the five evaluation dimensions established for permanence in the National Postgraduate System (SNP). The study prioritises the analysis of the management process over the measurement of isolated results (Abero *et al.*, 2015; Trujillo *et al.*, 2019).

The study is organised into two phases. Phase 1, called context, describes the structure and management processes of a non-classroom postgraduate program through five sequential stages. Phase 2, called evaluation, operationalises the five dimensions of the National Postgraduate Program (PNPG), translating each into evaluable criteria, suggested indicators, required evidence, and improvement actions. For this purpose, the PNPG Guidelines (DOF, 2025), institutional documents of the MTIE program, and specialised academic literature were analysed, and evaluation tables were constructed for each dimension. The correspondence between Phase 1 and the PNPG dimensions is as follows: Stage 1 (viability and academic core) supports Dimension 1 (academic capacities); Stage 2 (curriculum) supports Dimension 3 (relevance); Stage 3 (community engagement) supports Dimension 5 (commitment to society); and Stage 4 (tutoring and thesis supervision) supports Dimension 2 (student development). Stage 5 (infrastructure) complements the criteria of Dimension 1. Dimension 4 (inclusion and substantive equality) is addressed transversally as an institutional condition that permeates all stages of the management process.

Phase 1 (context) comprises five sequential stages for the operation of a non-classroom postgraduate program: (1) Viability study and formation of the academic core; (2) Curriculum and teaching-learning process; (3) Engagement with sectors of society; (4) Monitoring of academic progress, mentoring, and thesis supervision; (5) Infrastructure and institutional commitment. Each stage provides documentary data and evidence that support the evaluation of the corresponding dimensions of the National Postgraduate System (SNP) in Phase 2.

In the first stage, starting from the assumption that a viability study exists, the next strategy is to form a group of teacher-researchers to create an academic core (NAB). Therefore, the master's program in emerging information technologies was developed by members of two academic cores (CA): the Computer Science Group (CC) and the Information and Communication Technologies for Teaching and Learning Group (TICEA). Both groups are composed of teacher-researchers, and some members belong to the National System of Researchers (SNII). However, each group cultivates Lines of Research and Social Impact (LPIS) that guide their academic production and differentiate their disciplinary approach.

For the CC group, the LPIS encompass human-computer interaction and distributed networks and systems; for the TICEA group, the LPIS focus on information technologies, communications, and collaboration for learning. Considering the above and based on the needs of the region and the continuity of the undergraduate teaching programs of the HEI, the master's program arises, aiming, simultaneously, to consolidate the commitment of the program's collaborators, that is, to form the Academic Core of the postgraduate program.

Stage 2 focuses on the curriculum and its relevance; that is, the rationale of the postgraduate program is vital for the development of the teaching-learning process, considering the institutional guidelines and the code of good practices of the National Postgraduate Quality Program (PNPC) (CONACYT, 2018). The General Directorate of Research and Postgraduate Studies (DGIP) is responsible, as an internal institutional entity, for ensuring the quality of postgraduate programs.

The rationale of the program encompasses four key elements: (a) admission requirements, including a standardised selection process using the CENEVAL EXANI-III (2024); (b) curriculum and duration (four semesters for the master's degree, six for the doctorate), with elective subjects that reinforce the final project and strengthen internationalisation; (c) course completion requirements, which include the publication of at least one article in high-impact indexes (Scopus, Web of Science) and outreach activities; and (d) monitoring of academic progress and tutoring, which is developed in Stage 4. The details

of the indicators, evidence, and improvement actions for each of these elements are presented in Dimension 3 (program relevance) of the Results section.

In the third stage, engagement with sectors of society essentially involves collaboration with the target sector of the postgraduate program, obviously through complementary activities, such as mentoring, projects, fieldwork, and academic collaboration with students in seminars, workshops, colloquia, discussions, or complementary activities with other similar postgraduate programs. Evidence of this engagement includes collaboration agreements, letters of intent, socially recognised projects, and joint activities among the program, the Academic Groups, and the priority sectors of the region.

In stage 4, concerning the monitoring of academic progress, tutoring, and thesis supervision, it is essential that a non-classroom program has a tutoring model. This means that monthly academic tutoring must be a priority, with each student assigned to a tutor from the moment they enter the postgraduate program. This personalised support will help improve academic performance and prevent students from dropping out of the course or falling behind. This tutoring model must include verifiable instruments that document the monthly tutoring sessions and value synchronous communication, whether virtual or in person, which must take place at least once a month. Regarding thesis supervision, it is important to clarify the number of students per supervisor and to ensure their validation by the academic body. It is worth noting that the academic tutor has a different function from that of the thesis supervisor.

Finally, stage 5, concerning infrastructure and institutional commitment, relates to guaranteeing the availability, 24 hours a day, 7 days a week, of the institutional educational platform, as well as compliance with technical responsibilities and the consolidation of improvements in the technological infrastructure. It also includes maintaining access to digital libraries and inter-institutional agreements for access to bibliographic resources. In this sense, institutional commitment is necessary to ensure that academic management and administrative processes are fully digital, as well as the constant updating of the learning platform to strengthen students' learning processes, such as videoconferences, virtual forums, among others.

4 RESULTS AND DISCUSSION

Based on the documentary analysis carried out in Phase 2, the assessment tables for each of the five dimensions of the SNP (DOF, 2025) are presented. For each dimension, evaluable criteria were identified, compliance indicators and verifiable documentary evidence were proposed, and improvement actions were formulated to strengthen the program's

continuous participation in the SNP. The results are organised according to the methodological structure described in Phase 1, showing how each management process of the program contributes to meeting the required quality standards.

Dimension 1. The academic capacities of the program are based on three criteria: (a) The Academic Core (NA) must meet the minimum number of members registered in the National System of Researchers (SNII). (b) The profile of the NA members. (c) The infrastructure capacities.

Therefore, for each criterion, supporting documentation is considered for the following suggested indicators, defined for evaluation by SECIHTI (2025), as well as the necessary evidence and improvement actions. In this sense, it is important to provide evidence for each criterion, whether on the master's program website or in downloadable documents shared on a server.

Table 1

Criteria of Dimension 1

Criteria	Suggested indicators	Required evidence	Improvement actions
Members of the academic core (NA).	Updated curriculum vitae, relation to the course taught, recent publications, participation in Research and Social Impact Lines (LIES), national/regional projects, and SNII recognition	Institutional document of the members of the Academic Group or of the core faculty. Letter of commitment from each member of the Academic Group to the program and the teaching-course relationship. Link to the complete curriculum vitae.	Keep curricula updated and strengthen ties with national/regional projects.
Profile of the NA members.	Teaching/research reports, current publications, outreach activities.	Evidence of the profile of the academic core faculty members, including outreach activities.	Encourage joint publications and expand outreach activities.
Infrastructure capabilities.	Inventory of equipment/software, academic platforms, and proof of use.	Technical and photographic proof of the platform used (hardware and software	Equipment maintenance and support, and certification of instructors in course delivery and platform use.

Source: prepared by the authors.

In this dimension, it is relevant to highlight the need for at least eight members in the National System of Research and Innovation (SNII), in accordance with the Guidelines published in the Official Gazette of the Federation (DOF) (2025) for criterion (a). It is essential that academic profiles are aligned with the objectives of each postgraduate program; however, ensuring that each faculty, school, or department integrates all the required professional profiles is practically impossible. Nevertheless, inter-departmental collaboration

can mitigate this type of difficulty. Cajigal-Molina and Hernández-Marín (2020) demonstrate that higher education institutions in the southeast face greater challenges than those in the central region of the country.

Dimension 2. The commitment to student development focuses on (a) graduation rates and academic delays among students enrolled in the program, as well as (b) student support and guidance (student/teacher ratio). It is emphasised that each student selects their supervisor based on their professional profile to promote empathy and alignment with their project. However, it is important to distinguish between academic guidance and disciplinary guidance. To this end, a thesis committee is established to balance the supervision and co-supervision of the thesis, guaranteeing the quality of the outcomes of the research projects.

Table 2

Criteria of Dimension 2

Criteria	Suggested indicators	Required evidence	Improvement actions
Graduation efficiency.	Graduation rate and delay per cohort.	Records of course completion examinations	Encouraging thesis committees to improve the advisor-student relationship.
Student support and guidance.	Formative tutoring model.	Monthly tutoring report with photographic evidence.	Strengthening of the tutoring model for each student with a tutor from the Teaching Assistants team from admission to the program.

Source: prepared by the authors.

Table 2 presents the criteria considered relevant for the evaluation of postgraduate programs within the framework of the National Postgraduate System (SNP), aligned with the stages of admission, permanence, completion, and awarding of degree. An average completion rate of 70% is established as a reference, considered an indicator of adequate efficiency in obtaining the degree. This parameter represents an institutional challenge, since it requires higher education institutions (HEIs) to commit to the implementation and consolidation of their respective Institutional Tutoring Programs (PITs). As Quezada-López (2017) points out, tutoring is a fundamental means of support for the prevention of low academic performance and school dropout, in addition to promoting increased completion rates. In this sense, tutoring is configured as a strategy that enables closer monitoring and effective communication with students.

Dimension 3. The relevance of the program of study is based on (a) congruence between the admission profile, the selection process, and the curriculum, as well as on (b) actions to strengthen the professional development of graduates and (c) actions to mitigate dropout rates.

Table 3 demonstrates that criterion (a) is evidenced by the application of the EXANI-III for postgraduate admission, with the aim of ensuring transparency and equity. This ensures that the selection process does not depend exclusively on internal assessments, reducing biases and guaranteeing equal conditions for all candidates. In addition, the use of the EXANI-III strengthens the administrative formality of the postgraduate program, demonstrating its adherence to national quality standards (Gago-Huguet, 2000) and making its admission processes verifiable and comparable.

Table 3

Criteria of Dimension 3

Criteria	Suggested indicators	Required evidence	Improvement actions
Congruence between the entry profile, a clear and transparent, relevant and equitable selection process, aligned with its objectives.	Mechanism for the selection and interview process. Coherence in advising and field of knowledge with respect to the curriculum and the thesis/dissertation. The graduate program is presented as a differentiating and relevant element compared to other similar programs.	National call for applications under CENEVAL for the EXANI-III examination, admission statistics, and evidence of diversity. Thesis and dissertation matrix document. Dissemination document. Mobility document. Regional/national impact document	Strengthen the internal selection processes in the NA, ensuring clarity and transparency to guarantee equity. Strengthen inclusion initiatives. Align graduate programs with strategic objectives. Disseminate the programs' achievements. Strengthen international mobility. Strengthen accreditations
Actions to strengthen the professional development of graduates.	Mechanism for follow-up and collaboration with alumni, demonstrating professional placement.	Institutional alumni follow-up document. SEAES institutional document. Provide proof of employment.	Strengthen digital mechanisms for alumni follow-up. Expand employment contracts
Actions to mitigate school dropout.	Mechanisms to address and reduce school dropout and improve student retention.	Informational document on national, institutional, and state scholarships. Document on psycho-emotional support services.	Make institutional graduate regulations more flexible to strengthen support programs. Expand institutional support and national scholarships to contribute to student retention.

Source: prepared by the authors.

According to Ramírez Ramírez and Ortega-Guerrero (2018), international mobility fosters the development of social and cultural capital, which can be leveraged in the future in the personal, social, and professional spheres. It also strengthens institutional commitment to postgraduate programs, especially those linked to the National Postgraduate System (SNP). In this sense, promoting student mobility, even for short-term stays, is a fundamental strategy for fostering the professional development of students and driving internationalisation.

One of the actions to demonstrate (b) actions to strengthen the professional development of graduates is the participation of postgraduate programs in the institutional document of the SEAES. The System for the Evaluation and Accreditation of Higher

Education (SEAES) constitutes the national framework that regulates how higher education programs and institutions are evaluated and accredited in Mexico, integrating both internal self-assessment and external accreditation, with the aim of guaranteeing quality, relevance, and continuous improvement. This document includes the monitoring of graduates until they become fit for the labour market within an institutional framework, in addition to presenting well-defined strategies, as pointed out by López Obando and Villamil Bolívar (2019).

Finally, it is necessary to highlight the actions taken to reduce dropout rates, including the dissemination of information about institutional support programs, scholarships and state or national loans, and national scholarships to help students stay in school. The various student support services offered by the Secretariat of Student Affairs or equivalent department of any higher education institution must also be described.

Dimension 4. The commitment to inclusion and substantive equality encompasses institutional actions aimed at guaranteeing equitable conditions of access, permanence, and course completion for all students of the program, regardless of their gender, origin, socioeconomic condition, or vulnerability. This dimension permeates the entire program and requires evidence both in the admission processes and in the organisational culture of the postgraduate program.

Table 4

Criteria of Dimension 4

Criteria	Suggested indicators	Required evidence	Improvement actions
Actions for substantive equality.	Mechanism to identify profiles of students in vulnerable situations and promote equity in access to academic opportunities and reduce dropout rates.	Demonstrate the dropout rate and the mechanisms for resolving academic equality disputes. Protocols for the prevention of and response to gender-based violence and workplace violence.	Scholarship support program; strengthen mentoring programs. Institutional dissemination of protocols on gender-based violence and workplace violence

Source: prepared by the authors.

In this dimension, as demonstrated in Table 4, it is essential to highlight the institutional mechanisms implemented for the prevention of and response to gender-based violence and workplace violence, as well as for the promotion of equality and the resolution of academic conflicts. It is indispensable to recognise that every person – regardless of gender, ethnicity, or condition – who is a victim of violence or discrimination must be treated and protected equitably, guaranteeing the same rights and obligations. This perspective is based on the work of Gutiérrez Bernal and Navarrete Sánchez (2023).

In addition, non-classroom programs face the specific challenge of guaranteeing full digital accessibility: the educational platform, materials, and assessment mechanisms must be accessible to students with visual, auditory, or motor disabilities. This implies not only compliance with the Web Content Accessibility Guidelines (WCAG), but also the existence of institutional protocols for differentiated support. Similarly, it is important to highlight the affirmative action initiatives aimed at groups historically under-represented in postgraduate programs in science and technology, such as women, indigenous students, and people from highly marginalised geographical areas (Soto-Grant and Castro-Garro, 2024).

Dimension 5, Commitment to Society, focuses on linking the program to priority sectors for the development of the region and of Mexico; social responsibility initiatives; and inter-institutional cooperation. In this dimension, it is important to highlight all the outcomes of the postgraduate program, from collaboration agreements with other higher education institutions and inter-institutional projects to the social contributions of postgraduate students.

In this dimension, it is essential to demonstrate explicitly to the National Postgraduate System (SNP) the social outreach activities carried out by the postgraduate programs. As Zarza-Delgado and Herrera-Tapia (2024) mention, these activities must be conceived as an institutional measure aimed at strengthening and developing the social engagement of postgraduate programs. In this sense, it is not enough simply to recognise the activities carried out by students; it is necessary to consolidate the impact of research in addressing the problems of the communities where the programs are located, thus ensuring their tangible impact on society.

Finally, inter-institutional collaboration or cooperation can be demonstrated through partnership agreements between higher education institutions, academic bodies, or research groups. The active participation of Academic Core members in these initiatives — whether through seminars, research meetings, or other joint activities — contributes to strengthening the continuing education of the community of Science, Humanities, Technology, and Innovation (CHTI).

Table 5

Criteria of Dimension 5

Criteria	Suggested indicators	Required evidence	Improvement actions
Link the program to priority sectors for the development of the region and Mexico	The alignment and connection of the program with priority sectors for the development of the region and Mexico. Establishment of ties with relevant social actors for the advising and continuing education of the Science,	Collaboration agreements or letters of intent. Interinstitutional agreements, joint projects, collaborative publications, academic mobility	Diversify projects, strengthen ties with strategic sectors.

	Humanities, Technology, and Innovation (CHTI) community.		
Social responsibility initiatives.	Incorporate social responsibility activities that enable active participation in the benefits of knowledge	Outreach and dissemination activities, community activities, knowledge transfer.	Increase community activities through knowledge transfer, measure social impact.
Interinstitutional cooperation.	Academic links between higher education institutions, with information on academic and research activities coordinated with other institutions.	Interinstitutional agreements, joint projects, collaborative publications, academic mobility	Expansion of collaboration networks, promotion of academic mobility.

Source: prepared by the authors.

5 CONCLUSION

The analysis carried out makes it possible to affirm that the evaluation of non-classroom postgraduate programs in Mexico requires comprehensive management that integrates both the academic capacities and the social relevance of the programs. The guide of good practices presented demonstrates that continuous participation in the National Postgraduate System (SNP) depends not only on compliance with administrative requirements, but also on the consolidation of training, inclusion, and community engagement processes.

In summary, the management proposal presented constitutes a replicable guide for non-classroom postgraduate programs, capable of adapting to regulatory changes and responding to the requirements of quality, relevance, and social impact required by the SNP.

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PHOTOVOLTAIC SOLAR POWER GENERATION SYSTEMS: POTENTIAL AND CHALLENGES FOR ARCHITECTS AND URBAN PLANNERS

SISTEMAS DE GERAÇÃO DE ENERGIA SOLAR FOTOVOLTAICA: POTENCIAL E DESAFIOS PARA ARQUITETOS E URBANISTAS

SISTEMAS DE GENERACIÓN DE ENERGÍA SOLAR FOTOVOLTAICA: POTENCIAL Y RETOS PARA ARQUITECTOS Y URBANISTAS

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ABSTRACT

Given the urgency posed by the climate crisis, the drive towards energy transition and the potential of solar photovoltaic energy, there has been limited adoption of this technology by architects and urban planners, particularly of BIPV (Building-Integrated Photovoltaics) modules, highlighting a disconnect between design practices and available innovations. The aim is to investigate the reasons for the low adoption of photovoltaic technology by professionals in the São Paulo Metropolitan Region, analysing the potential of BIPV and other factors and constraints that may influence this low adoption. To this end, a literature review, documentary research, and a quantitative-qualitative study were conducted, involving an online questionnaire administered to 124 architects and urban planners, as well as interviews with experts. It is noted that a lack of knowledge, particularly regarding BIPV solutions, is the main factor explaining the low adoption rate, followed by the cost of implementation and the negative aesthetic impact of such solutions, which, although relevant, does not influence the choices of architects and urban planners. It is therefore concluded that this research fills a gap in the debate on the role of these professionals in the energy transition, promoting the dissemination and integration of photovoltaic energy in Brazilian architecture.

Keywords: Photovoltaic Solar Energy. BIPV. Solar Architecture. Architect and Urban Planner.

RESUMO

Considerando a urgência colocada pela crise climática, a busca pela transição energética e o potencial da energia solar fotovoltaica, observa-se uma reduzida adoção dessa tecnologia por arquitetos e urbanistas, especialmente dos módulos BIPV - Building Integrated Photovoltaics, evidenciando um descompasso entre as práticas projetuais e as inovações disponíveis. Objetiva-se investigar os motivos da reduzida adoção da tecnologia fotovoltaica por profissionais da Região Metropolitana de São Paulo, analisando o potencial dos BIPV e demais fatores e condicionantes que podem influenciar para a reduzida adoção. Para tanto, procede-se à revisão bibliográfica, pesquisa documental, e estudo quanti-qualitativo, com aplicação de questionário online a 124 arquitetos e urbanistas, e entrevistas com especialistas. Observa-se que a falta de conhecimento, especialmente sobre as soluções BIPV, é o principal fator que explica a reduzida adoção, seguida pelo custo de implantação e o impacto estético negativo de tais soluções, que, apesar de relevante, não influencia a

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escolha dos arquitetos e urbanistas. Conclui-se, portanto, que a investigação preenche uma lacuna no debate sobre o papel desses profissionais na transição energética, promovendo a disseminação e integração da energia fotovoltaica na arquitetura brasileira.

Palavras-chave: Energia Solar Fotovoltaica. BIPV. Arquitetura Solar. Arquiteto e Urbanista.

RESUMEN

Teniendo en cuenta la urgencia que plantea la crisis climática, la búsqueda de la transición energética y el potencial de la energía solar fotovoltaica, se observa una escasa adopción de esta tecnología por parte de arquitectos y urbanistas, especialmente de los módulos BIPV (Building Integrated Photovoltaics), lo que pone de manifiesto un desajuste entre las prácticas de diseño y las innovaciones disponibles. El objetivo es investigar las razones de la escasa adopción de la tecnología fotovoltaica por parte de los profesionales de la Región Metropolitana de São Paulo, analizando el potencial de los BIPV y otros factores y condicionantes que pueden influir en dicha escasa adopción. Para ello, se lleva a cabo una revisión bibliográfica, una investigación documental y un estudio cuantitativo-cualitativo, con la aplicación de un cuestionario en línea a 124 arquitectos y urbanistas, y entrevistas con especialistas. Se observa que la falta de conocimiento, especialmente sobre las soluciones BIPV, es el principal factor que explica la escasa adopción, seguido del costo de implementación y el impacto estético negativo de dichas soluciones, que, a pesar de ser relevante, no influye en la elección de los arquitectos y urbanistas. Se concluye, por lo tanto, que la investigación llena un vacío en el debate sobre el papel de estos profesionales en la transición energética, promoviendo la difusión e integración de la energía fotovoltaica en la arquitectura brasileña.

Palabras clave: Energía Solar Fotovoltaica. BIPV. Arquitectura Solar. Arquitecto y Urbanista.

1 INTRODUCTION

The global climate crisis and the advance of environmental impacts caused mainly by the emission of greenhouse gases (GHG), combined with the growing worldwide demand for electricity, have driven the energy transition towards renewable sources with low environmental impact. In this contemporary scenario, solar photovoltaic energy presents itself as a promising alternative for the development and achievement of more sustainable energy matrices, potentially contributing strategically to the reduction of GHG emissions and to the increase in electricity generation as a replacement for polluting sources, especially fossil fuels, which have a major environmental impact.

Brazil stands out worldwide in relation to the use of renewable energy sources: 50.0% of the national energy matrix and 88.2% of the country's electricity come from renewable sources, compared to worldwide percentages of 14.3% and 29.9%, respectively (MME, 2025). However, hydroelectric generation accounts for 11.6% of the national energy matrix and 56.8% of the country's electricity. Although this energy source is considered renewable, the environmental and socio-economic impacts arising from its installation – such as the flooding and deforestation of vast areas, with loss of biodiversity and the forced displacement of riverside communities and indigenous peoples – as well as the physical limits to its expansion – mainly of a geographical and hydrological nature – demand the search for other available energy sources.

Solar photovoltaic energy, despite contributing only 2.2% of the national energy matrix and 9.3% of the electricity generated, is growing in Brazil. In 2024, the country reached more than 53 GW of installed capacity, compared to 25 GW in 2022, ranking, in absolute terms, sixth among the countries with the largest installed solar power capacity in the world, behind only China, the USA, Japan, Germany and India (MME, 2025; IRENA, 2026). This growth has been driven by technological advancement, which enables the decentralisation of electricity generation, as well as by the gradual reduction in the installation and maintenance costs of photovoltaic systems. Furthermore, between 2012 and 2023, under Normative Resolution REN 482, of 17 April 2012⁴, it can be said that there was a favourable environment for its expansion, with incentives and guarantees from the current legislation, and the establishment of objective rules for the sector (Madeira, 2025).

The expanded use of photovoltaic technology has been occurring in two ways: (i) with the deployment of large power plants, generally in rural areas and associated with centralised systems, using transmission lines so that the energy produced can be conveyed to the points of consumption; and (ii) with the installation of photovoltaic systems in buildings and their

⁴ REN 482 established the general conditions for the access of MMGD to electricity distribution systems, the electricity compensation system (ANEEL, 2012).

surroundings, at the points of consumption themselves, so-called “distributed generation”, also referred to as “distributed micro- and mini-generation” (MMGD).

In MMGD, the installation of photovoltaic systems has been carried out on existing buildings and, more frequently, on roofs and rooftops, where there is greater solar incidence, but such surfaces do not always have sufficient dimensions to meet the entire energy demand of the buildings. In these cases, conventional *Building Applied Photovoltaics* modules, the BAPV, are generally used, which are “added” to the buildings, without there necessarily being any integration with the architecture, that is, without any concern for the aesthetic outcome of the solutions adopted.

In recent years, photovoltaic technology has advanced with innovative solutions in the form of *Building Integrated Photovoltaics*, the BIPV, which are modules that integrate energy-generating systems into the building elements, reconciling energy efficiency and architectural aesthetics (Custódio; Reis, 2023; Koike; Custódio; Rüther, 2023; Zomer; Crestani, 2023). The growth of photovoltaic energy in Brazil could be even greater if architects and urban planners – fundamental and strategic agents in the design and production of the built environment – adopted this technology in their projects.

However, it was observed that photovoltaic energy is still little used by these professionals, even in projects for new buildings: an analysis of the main publications in the field of Architecture and Urbanism in the country⁵ revealed that only 11.7% of the projects and works published in 2023 included photovoltaic systems, most of them with BAPV modules (Madeira, 2025). The evidence of low adoption of photovoltaic technology points to a disconnect between recent design practices, the new solutions available and the potential contribution of architects and urban planners to the expansion of this technology. It is therefore necessary to broaden the debate on the role of these professionals in the energy transition process, highlighting their capacity to influence design decisions and electricity consumption in cities.

Starting from this context, this article aims to present and discuss the main results of doctoral research that sought to investigate the reasons why architects and urban planners do not adopt, or adopt with low frequency, solar photovoltaic power generation systems in market architectural projects, with the São Paulo Metropolitan Region (RMSP) as the territorial scope⁶. As specific objectives, it intends to: (i) identify and analyse BIPV-type photovoltaic

⁵ To assess the use of photovoltaic technology in the recent period, the following were consulted: (i) the AU Magazine, (ii) the platform *Archdaily* and (iii) the *Projeto Magazine* – all responsible for disseminating the most prominent and representative architecture and urbanism projects and works in the Brazilian context.

⁶ This doctoral research was developed in the Graduate Program in Energy of the Universidade Federal do ABC, between 2019 and 2025, under the supervision of Prof. Dr. Federico B. Morante Trigoso and cosupervision of Prof. Dr. Patrícia T. Leite Asano.

systems and their potential for integration with buildings, and (ii) survey and analyse, through quantitative and qualitative research, the level of knowledge and the degree of importance of factors postulated by the researcher, as well as other factors, that could influence the adoption or non-adoption of such systems by architects and urban planners.

The hypothesis formulated related the non-adoption or the low-frequency adoption of photovoltaic technology to three main factors: **lack of knowledge** of the available solutions, especially BIPV; **negative aesthetic impact** and (high) **cost of implementation** of such solutions. It was also considered that the factor **negative aesthetic impact** would be directly related to the **lack of knowledge** of the technology and the available solutions. In other words, architects and urban planners would be failing to specify photovoltaic systems because they are unaware of solutions that can minimise such impacts or even contribute to the improvement of the architectural design.

Considering that there are few studies related to the existing dynamics between the work of professionals in the field of architecture and urbanism and the expansion of photovoltaic technology, this research contributes both to filling this gap and to disseminating, among architects and urban planners, the possibilities of integrating photovoltaic systems into buildings. More broadly, it contributes to promoting the expansion of energy generation from renewable sources.

2 THEORETICAL BACKGROUND

The development of the research had as its starting point the survey, analysis and literature review of two themes that are interrelated and connected to the object of the research: Net Zero Energy Building (*NZEB*) (Koike; Custódio; Rütther, 2023; Good et al., 2016; Scognamiglio; Garde, 2015) and Solar Architecture (Custódio et al., 2020; Custódio; Reis, 2023; Koike; Custódio; Rütther, 2023; Zomer; Crestani, 2023; Custódio; Zomer; Rütther, 2020).

Contemporary literature emphasises the evolution of buildings from mere consumers to producers of energy, consolidating the concept of Net Zero Energy Buildings (NZEB). Such buildings produce their own electricity, locally, in a renewable way, in a quantity sufficient for their annual demand, that is, there is a balance between the amount of energy consumed and the amount of renewable energy produced.

In addition to these buildings, there are also those with nearly zero energy needs, known as nZEB – *nearly-Zero Energy Building*: although they still need to consume electricity from the distribution grid, they already achieve a satisfactory degree of economy as a result of

the renewable energy generated, that is, they are buildings with very high energy performance (Good *et al.*, 2016).

In Europe, zero or nearly zero energy balance is becoming an obligation: through the Energy Performance of Buildings Directives (EPBD) 2010/3 and 2024/1275, the European Union pioneered the establishment of mandatory standards and targets for zero-emission buildings, both for new constructions and for the renovation of buildings. Achieving NZEB or nZEB involves the implementation of strategies aimed at optimising consumption and maximising the production of renewable energy, with emphasis on the installation of solar photovoltaic power generation systems.

However, studies indicate that, in most cases, the energy balance is not achieved solely by using the roof area of buildings for the installation of these systems, which demands the incorporation of façades and other elements of the building envelope for this purpose (Scognamiglio; Garde, 2015). Such a finding raises the importance of the aesthetic and functional integration of the technology into the architecture, where photovoltaic systems cease to be an “appendage” and become a multifunctional component of civil construction (Custódio; Reis, 2023).

Solar architecture is a design approach that seeks to optimise the use of solar energy to meet the energy needs of a building, minimising the consumption of non-renewable resources and promoting environmental comfort. In general, solar architecture can be understood from two main approaches: passive and active⁷.

Passive solar architecture consists of the direct use of light and heat from the sun, without the need for conversion into electricity or the use of complex mechanical equipment; it is based mainly on the choice of materials for the capture, storage and distribution of solar heat and light in buildings, in a natural way, that is, it involves passive mechanisms of thermal comfort.

Active solar architecture, on the other hand, involves the use of technological devices and mechanical systems to convert solar energy into other forms of energy. The main active components are (i) solar thermal collectors, which heat fluids – usually water – for sanitary use and space heating; and (ii) photovoltaic systems, which convert sunlight directly into electricity, through the photovoltaic effect. In a complementary manner, active solar architecture advocates the use of technological systems as active components – in substitution for or in complement to passive architectural elements, such as roofs, brises, cladding and façades – which, in addition to performing the conventional functions of shading,

⁷ The adoption of solar architecture – passive or active – combined with other bioclimatic strategies – such as natural ventilation and lighting, thermal insulation – enables the creation of environments with greater comfort and lower environmental impact, while also being energy efficient. For more information, see Lamberts, Dutra and Pereira (2014).

sealing and protection, can also generate electricity from solar radiation (Custódio *et al.*, 2020; Custódio; Reis, 2023; Zomer; Crestani, 2023).

Such an approach is not new, but its technical and aesthetic maturation has kept pace with the advances in photovoltaic technology, especially with the development of BIPV modules, which, in addition to generating energy, can also perform other constructive functions (Custódio *et al.*, 2020; Koike; Custódio; Rüther, 2023). Thus, BIPV represent one of the most promising solutions for the dissemination of solar photovoltaic energy in architecture, standing out both for enhancing the harmony between energy performance and the architectural concept, and for optimising the use of the built surface of buildings for energy generation (Koike; Custódio; Rüther, 2023; Custódio; Zomer; Rüther, 2020).

Although the adoption of BIPV is still incipient in Brazil, their growth potential is significant, especially in institutional, commercial and medium- to high-standard residential buildings, but also in Social Housing (HIS) projects (Zomer; Crestani, 2023; Custódio; Reis, 2023). However, there are few studies that relate the advances and possibilities of BIPV to the existing dynamics between the work of professionals in the field of architecture and urbanism and the expansion of photovoltaic technology, in the direction of the energy transition. The proposed research seeks to contribute to filling this gap and updating the debate in Brazil.

3 METHODOLOGY

In addition to the survey, analysis and literature review addressed in Section 2 – Theoretical Background –, the following methodological strategies were adopted in the research: (i) documentary research and analysis; (ii) quantitative and qualitative research, with the application of a questionnaire to architects and urban planners of the RMSP⁸; as well as (iii) interviews with experts on the photovoltaic theme.

The documentary research and analysis involved: the characterisation of photovoltaic systems, notably BIPV; the identification of strategies for disseminating photovoltaic technology by the Brazilian market; the study of the inclusion of content related to photovoltaic energy in the curriculum of six undergraduate courses in Architecture and Urbanism in the state of São Paulo; and the analysis of the relevant legislation.

The development of the quantitative and qualitative research included: the definition of the sample universe, in a statistical way⁹; the formulation and implementation of strategies to

⁸ The RMSP is composed of 39 municipalities and has 20.7 million inhabitants (IBGE, 2022). The state of São Paulo concentrates about one third of the architects and urban planners registered with the Council of Architecture and Urbanism – 70 thousand of 220 thousand professionals – with almost 60% – 40.7 thousand professionals – residing in and working in the RMSP (CAU/SP; CEBRAP, 2023).

⁹ To determine the sample size, the “sample calculation for finite populations” methodology was used (Gil, 2008), with a confidence level of 95% and a margin of error of up to 10%. The sampling calculation resulted in 96 questionnaires in total.

contact architecture and urbanism professionals and firms, which resulted in the participation of 172 professionals in the research, 124 of whom worked in the RMSP; the conducting of a pre-test; and the provision of an online questionnaire, for the survey of information on (a) the level of knowledge about photovoltaic technology, (b) the degree of importance of the postulated factors, which could influence the adoption or non-adoption of photovoltaic systems, as well as (c) aspects of the undergraduate education and continuing training of the professionals, (d) the influence of clients and partners, and (e) dissemination strategies of the Brazilian photovoltaic market.

The interviews deepened the themes addressed in the questionnaire, exploring the experiences and critical views of the experts regarding the use of photovoltaic systems.

Finally, the systematisation, tabulation, cross-referencing and analysis of the answers to the multiple-choice and essay questions were carried out, which made it possible to outline a panorama of the perception of architecture and urbanism professionals in relation to photovoltaic technology and to identify the main factors that would explain the non-adoption or the low-frequency adoption of solar photovoltaic power generation systems, in response to the hypothesis formulated.

4 BIPV-TYPE PHOTOVOLTAIC MODULES: POTENTIAL AND CHALLENGES FOR USE

As already mentioned, there are two types of photovoltaic modules: (i) BAPV – *Building Applied Photovoltaics* –, modules that are attached or added to buildings, generally existing ones; and (ii) BIPV – *Building Integrated Photovoltaics* –, modules that are directly integrated into or replace architectural elements, such as façades, roofs, brises and glass. BIPV modules come in various shapes, sizes, colours and textures, with semi-transparent, flexible, bifacial and even textured solutions; however, BIPV still cost more than BAPV. Nevertheless, the replacement of passive materials with multifunctional active materials, such as BIPV, can result in financial benefit, since the cost of the conventional materials that are no longer used must be deducted from the initial investment in the photovoltaic solutions (Koike; Custódio; Rüther, 2023).

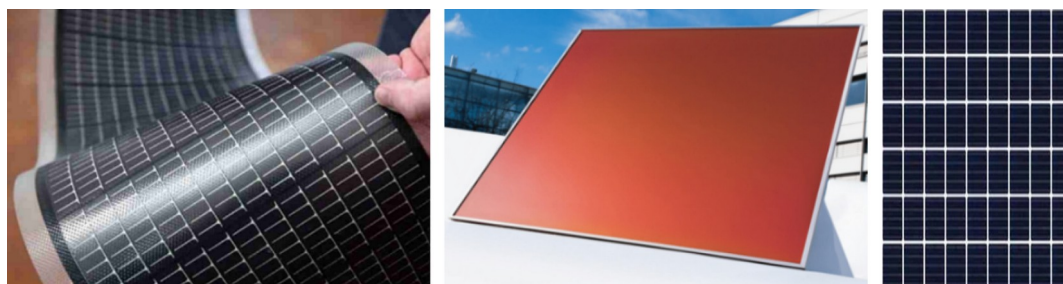
The growth of BIPV-type modules in the world market has been occurring in view of the advantages of these integrated systems, above all because of the aesthetic issue and multifunctionality, among others such as: (1) generation of renewable energy, (2) energy efficiency, (3) architectural performance, (4) property value appreciation, (5) reduction of energy costs, and (6) durability, with a minimum guarantee of 25 years, superior to that of conventional cladding (Zomer; Crestani, 2023). In Brazil, the most commercialised photovoltaic modules are conventional modules, the BAPV of the monocrystalline silicon or

polycrystalline silicon type. However, there is already a concern in the national market to expand the commercialisation of integrated modules, the BIPV. The main models available in Brazil or for import are:

- **Flexible Thin Film modules** (Figure 1): more usual and common, they are used on curved surfaces, or directly on tiles, roofs or façades, having as their main characteristic, in addition to flexibility, lightness;
- **Coloured and Textured modules** (Figure 2): still little used in Brazil, they can replace façades with smooth cladding or glass-skin type; there are countless colours, including textured ones, that imitate other construction materials;
- **Bifacial modules** (Figure 3): quite common in Brazil, they are used in atriums, skylights and structures for covering vehicles (carports); their main characteristic is to generate energy on both sides, being usually installed in large and often open places, where solar incidence occurs both directly from the upper part, and diffusely from the lower part.

Figures 1, 2 and 3

BIPV module types: Thin-film flexible, Colored, and Bifacial



Source: Madeira (2025).

Figures 4, 5 and 6 present examples of the use of BIPV-type photovoltaic modules in brises, façades and roofs, respectively.

Figures 4, 5 and 6

Application of BIPV modules: Thin-film flexible, Colored, and Bifacial types



Source: Madeira (2025).

The Edmonton Convention Centre, in Canada (Figure 7), and the Copenhagen International School, inaugurated in 2017 in Denmark (Figure 8) – in which the photovoltaic modules cover the entire façade, replacing the cladding materials – are considered emblematic cases of BIPV use in the world. In Brazil, the pioneering experiences of the headquarters of the company TOTVS (Figure 9), inaugurated in 2017, and of the Germinare school (Figure 10), both in São Paulo, demonstrate the potential for using such systems in urban contexts, as well as the possibilities of integration with the architecture. At the TOTVS headquarters, the flexible photovoltaic modules are associated with part of the façade glazing: in addition to generating energy, the photovoltaic modules reduce the thermal load by around 75% by blocking part of the UV rays, also reducing the building's energy consumption (Madeira, 2025). At the Germinare school, the original project conceived in 2009 provided for the subsequent installation of brises with thin photovoltaic film which, in addition to producing solar energy, keep the internal temperature of the building much more pleasant, and also confer a contemporary aesthetic, both for the windows and for the façade (Zomer; Neris, 2023).

Despite the advantages, the adoption of integrated photovoltaic systems faces some challenges. The first concerns technical issues, which involve specifications of shading, solar orientation, angle of inclination, compatibility of constructive elements and maintenance aspects, which must be considered for their adequate performance. The second challenge refers to symbolic issues: many architects perceive solar modules as visual interferences, associating them with an “aesthetic contamination” of the architecture. This occurs, above all, when the systems are specified after the design of the project (Prieto; Ondenhave, 2021). This perception reinforces the relevance of BIPV in relation to BAPV, regarding the aspect of integration with the architecture.

Figures 7, 8, 9 and 10

Edmonton Convention Centre (Canada); Copenhagen International School (Denmark); TOTVS company headquarters (São Paulo); Germinare Business headquarters, J&F Institute (São Paulo)



Source: Madeira (2025).

Finally, it is worth highlighting that, although solar photovoltaic power generation presents low environmental impact, photovoltaic modules are not completely free of impact, especially at the end of their useful life, which demands the implementation of sustainable alternatives for the treatment of the waste generated when these systems are uninstalled (Miranda, 2019). Such treatment necessarily involves the appropriate disposal, reuse or recycling of the components of the photovoltaic modules. Federal Decree No. 10,240/2020 (Brasil, 2020) regulated the implementation of a mandatory reverse logistics system for electronic products – including solar photovoltaic panels – with the definition of responsibilities for manufacturers, importers, distributors and traders, aiming at the collection, transport, treatment and appropriate disposal of the waste from these products. The implementation of public policies aimed at recycling the components through the enhancement of reverse logistics may be the best path for confronting and mitigating the possible environmental damage arising from the adoption of photovoltaic technology.

5 RESULTS AND DISCUSSION

The conducting of the quantitative and qualitative research resulted in the responses of 124 architects and urban planners of the RMSP to the online questionnaire hosted on the

Google Forms platform – structured in three parts, with 14 multiple-choice questions, accompanied by fields for additional comments – and made it possible to gather information and data, which were tabulated and analysed quantitatively and qualitatively.

The first part of the questionnaire, with eight questions (Q01 to Q08), covered questions directly related to the factors postulated by the researcher that would explain the non-adoption or the low-frequency adoption of photovoltaic systems by architects and urban planners – **lack of knowledge about photovoltaic technology** and, in particular, **about BIPV**; **negative aesthetic impact**; and **cost of implementation**. It sought to identify, in addition to the level of knowledge of the respondents, the degree of importance attributed to the postulated factors, individually or in a comparative manner. The answers to questions Q1 to Q08 pointed to:

- **level of knowledge about photovoltaic technology** mostly “medium” (41.1%) or “low” (37.1%);
- **level of knowledge about BIPV**: prevalence of the “low” level (50%), followed by the “medium” level (37.1%);
- **degree of importance** – low, medium or high – attributed to the factors **negative aesthetic impact** and **cost of implementation**, individually: “high degree of importance” for both factors – 67.7% and 54%, respectively;
- **degree of importance** attributed to the factors **level of knowledge about photovoltaic technology** and **about BIPV**, **negative aesthetic impact** and **cost of implementation**, when compared: both factors proved to be important for the comparisons between (i) **cost of implementation** and **negative aesthetic impact** (68.5%); (ii) **cost of implementation** and **level of knowledge about the technology** (47.6%); and (iii) **level of knowledge about the technology** and **level of knowledge about BIPV** (49.2%); as for the comparison between the factors **level of knowledge about photovoltaic technology** and **negative aesthetic impact**, 65.3% of the answers indicated that the **level of knowledge** is more relevant than the **negative aesthetic impact**, a factor pointed out as more relevant by only 4.8% of the respondents.

The second part of the questionnaire, with two questions (Q09 and Q10), sought to understand the behaviour and attitude of the respondents in relation to the intention to specify or not photovoltaic technology, with and without the influence of clients. When asked about the intention to specify such systems, autonomously and spontaneously, that is, without the request of the clients, 91.1% of the respondents were broadly in favour of their adoption,

choosing the alternative *“I would always specify them in my projects”*. Among the justifications, the environmental aspect – adoption of sustainable solutions (65.3%) – outweighed the aspect relating to the savings generated by the photovoltaic systems (25.8%). As for the intention to specify photovoltaic systems when requested by clients, 53.2% of the respondents chose the alternative *“regardless of whether it is requested or not, I always try to specify or attempt to convince my clients of the importance of solar photovoltaic power systems”*, while 46.8% answered *“I only specify solar photovoltaic power systems if requested by the client”*.

The third part of the questionnaire, with four questions (Q11 to Q14), was formulated with a different logic. For questions Q11 and Q12, statements were presented for the indication of the degree of relevance, through the attribution of a numerical value between 1 (least representative) and 8 (most representative) to each of the statements.

Q11 presented **five statements** regarding the intention and reasons that lead to the specification or non-specification of photovoltaic systems. It sought to confront the answers to Q11 with those of the first and second parts of the questionnaire, and to identify possible conflicts. Most of the interviewees indicated “high relevance” for the statement: *“I always specify or suggest to my clients to include photovoltaic energy in projects”* (54.0%). The alternative “low relevance” prevailed for **three statements** *“I do not specify photovoltaic energy because I do not have mastery of the technology”* (53.2%); *“I do not specify photovoltaic energy because the solar modules will harm the aesthetics of the project”* (87.9%); and *“I do not specify photovoltaic energy due to the high cost of implementation”* (52.4%). Only for the statement *“I only specify photovoltaic energy when it is requested by the client”*, both options “low relevance” and “high relevance” reached 42.7% of the total answers.

Next, Q12 presented **seven statements** on other possible factors, beyond those postulated in the hypothesis – such as the training of architects and urban planners, dissemination of photovoltaic technology by the market, the attitude of partner professionals and the influence of environmental aspects – that could contribute to some extent to the non-adoption or the low adoption of photovoltaic technology.

Most of the respondents indicated “high relevance” for **three statements**: (i) *“the Faculties of Architecture and Urbanism are not adequately preparing future professionals for the use of this technology”* (66.9%); (ii) *“there are no adequate professional updating courses available and/or accessible”* (48.4%); and (iii) *“there is no efficient dissemination by the market of the available photovoltaic systems or of their benefits”* (55.6%).

For another **two statements** related to environmental issues – sustainability and possible impacts – most of the respondents indicated “low relevance”: (i) *“solar photovoltaic*

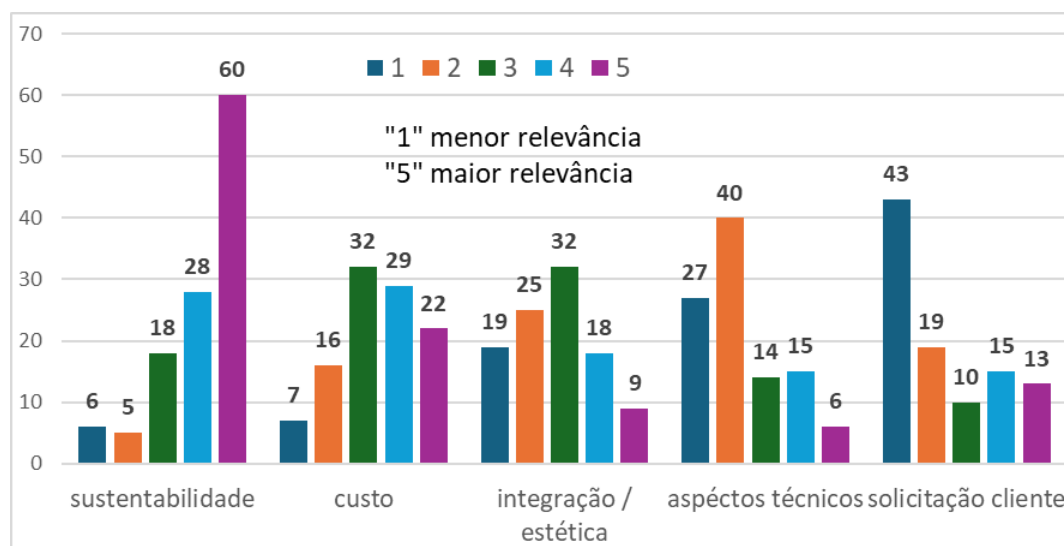
energy is not the best option for sustainable projects and for the preservation of the environment” (76.6%); and (ii) “photovoltaic technology also generates negative environmental impacts such as waste, and the life cycle of the materials is relatively short” – (48.4%).

However, **two statements** divided the group, with answers indicating a greater balance between the different degrees of relevance: (i) “partner professionals (mainly electrical engineers) discourage architects from using [photovoltaic technology] due to cost, technical issues or other factors”: “low relevance” (42.7%); “medium relevance” (25.8%); and “high relevance” (31.5%); and (ii) “photovoltaic technology contributes to economic development, but we live on a planet with limited natural resources, which would demand a slowing of the pace of development: “low relevance” (39.5%); and “high relevance” (35.5% of the total).

In question Q13, **five** (possible) **factors** related to the specification of photovoltaic systems were listed – **sustainability, cost, integration with the architecture/aesthetics, technical aspects** and **request by the client** – so that the respondents could rank each factor, from 1 to 5, according to its degree of relevance for the specification of the systems. The tabulated answers are represented in Graph 1.

Figure 11

Relevance of factors for adoption or non-adoption of photovoltaic technology



Source: Elaboration by the authors.

It was found that the factor that obtained the greatest number of answers as the one of “greatest relevance” was the factor **sustainability** (51.3%), followed by the factor **cost** (20.7%). The factor that obtained the greatest number of answers as the one of “least

relevance” was **request by the client** (43.0%), followed by the factor **technical aspects** (26.5%).

Finally, the last question of the third part (Q14) sought to ascertain the opinion of the respondents on the aesthetic outcome of a project with photovoltaic systems associated with the message conveyed by such a project: is it more relevant that the project conveys an image of sustainability, with the adoption of non-integrated modules (BAPV), or that the project incorporates integrated modules (BIPV), even if it does not clearly and evidently convey an image of sustainability? Most of the respondents (73.4%) indicated that they prefer to use integrated photovoltaic modules, which reveals a greater concern with the negative aesthetic impact of photovoltaic technology than with the message that such a solution might convey.

Based on the answers to the questionnaire, associated with the opinion of the experts, it was possible to outline a panorama of the perception of architects and urban planners in relation to photovoltaic technology, as well as to identify the potential and challenges to its adoption in the design process.

The answers to questions Q1 to Q4 showed that most of the respondents – around 80% – present reduced knowledge about photovoltaic technology, and an even lower level of knowledge about BIPV. They also indicated high importance for the factors “integration of the photovoltaic modules with the buildings and their aesthetic outcome” (67.7%) and “cost of implementation of solar photovoltaic power generation systems” (54%).

On the other hand, these results also revealed that few respondents present “high” knowledge about photovoltaic technology (21.8%) and about the available solutions integrated into buildings (12.9%); for this group of professionals, the importance in relation to the integration of the systems into the buildings is even greater (74.1%), while the importance in relation to cost is a little lower (44%). Thus, it can be deduced that the high knowledge about these systems results in greater knowledge about (i) the available solutions and their cost reduction over the last few years, (ii) the possibilities of providing for such systems in the design and their future execution, and (iii) other data and information that can contribute to the presentation and the convincing of clients for the adoption of the technology, including the aesthetic aspects.

The cross-tabulation of the answers to questions Q05 to Q08 – which related the three factors postulated in the hypothesis and their degree of relevance – indicated that the factor **lack of knowledge** about photovoltaic systems stood out in relation to the others, surpassing the factors **cost of implementation** and **negative aesthetic impact**, which occupied the

second and third positions, respectively, in terms of importance and influence on the specification of photovoltaic technology.

The answers to the second and third parts of the questionnaire indicate that:

- there is a high degree of acceptance of the technology, associated with the importance of adopting sustainable solutions, which can be measured by the answers to: (1) Q09 – “if it depended on them [architects and urban planners], they would always specify photovoltaic systems” (91.1%); (2) Q10 – “I always try to specify, regardless of whether it is requested by the client or not” (53.2%); (3) Q12 – low relevance for statement 5 “solar photovoltaic energy is not the best option for sustainable projects and for the preservation of the environment” (76.6%); and (4) Q13 – “sustainability” as the parameter of greatest relevance, in the decision to specify photovoltaic systems (51.3%);
- the factors **level of knowledge**, **negative aesthetic impact** and **cost of implementation**, presented independently, that is, not being compared with one another, present “low relevance” for the non-specification of the technology; however, in the case of the factor **negative aesthetic impact**, the high percentage of “low relevance” (87.9%) stands out in comparison with the percentages for the factor **level of knowledge** (53.2%) and **cost of implementation** (52.4%);
- both the education and the continuing training of architects and urban planners contribute to the low level of knowledge in relation to photovoltaic systems and BIPV – with “high relevance” (66.9%) for statement 1 of Q12 “*the Faculties of Architecture and Urbanism are not adequately preparing future professionals for the use of this technology*”, and 48.4% and 34.7% as “high” and “medium relevance”, respectively, for statement 2 of Q12 “*there are no adequate professional updating courses available and/or accessible*”; this finding of the research is corroborated by the experts: the lack of preparation generates the lack of knowledge, reflecting directly on the professional's decision on whether or not to use photovoltaic systems;
- the dissemination of the technology and of the products available by the market is not efficient, that is, it is not reaching the professionals in the field of architecture and urbanism, with 55.6% and 26.6% as “high” and “medium relevance”, respectively, for statement 3 of Q12 “*there is no efficient dissemination by the market of the available photovoltaic systems or of their benefits*”; for the experts consulted, there is no exclusive targeting of the dissemination towards the architect but rather towards the professionals who work with photovoltaic energy in general, including architects: the dissemination for the architecture and urbanism professional could have another

approach, in a more specific way, and include the dissemination of BIPV-type modules and of the principles of solar architecture;

- the relationship with partners, in particular with electrical engineers, is neither a motivating nor a demotivating factor for the specification of the technology – due to the more balanced percentages of the answers to statement 4 of Q12 “*partner professionals (mainly electrical engineers) discourage architects from using it due to cost, technical issues or other factors*” (31.5% “high relevance”, 25.8% “medium relevance”, and 42.7% “low relevance”).

Finally, it is worth mentioning that the environmental dimension is a central aspect for architects and urban planners: behind the decision or intention to specify photovoltaic systems, the sustainability factor appeared prominently. However, the vast majority of the professionals who answered the questionnaire prefer to specify a system integrated into the building, that is, a BIPV system; in this sense, the sustainability message, which would be highlighted with BAPV solutions, did not prove to be as relevant as the integration of the photovoltaic technology with the architecture, which indicates that the factor negative aesthetic impact must be considered in the preparation of the project.

6 CONCLUSION

The research presented and discussed in this article sought to understand the dynamics that exist between the work of architects and urban planners and the expansion of solar photovoltaic energy, with the main focus being to identify the reasons that lead such professionals not to adopt, or to adopt with low frequency, the use of this technology.

From the 124 answers to the questionnaire of the quantitative and qualitative research, it was possible to respond to the hypothesis formulated, as well as to identify other factors and constraints that can influence the adoption or non-adoption of photovoltaic technology.

The answers to the first part of the questionnaire, in particular, indicated that the factor of greatest relevance, among the three factors postulated in the hypothesis, corresponds to the **lack of knowledge of architects and urban planners about photovoltaic systems** and, in particular, **in relation to BIPV**, followed by the factor cost of implementation. Although architects and urban planners point to a high degree of relevance for the integration of the photovoltaic modules with the buildings and their aesthetic outcome, the importance of the factor negative aesthetic impact for the adoption of photovoltaic technology was relativised by the research findings.

In addition, it was found that both academic education and continuing training, as well as the inefficient dissemination of photovoltaic technology by the Brazilian market, contribute to the low level of knowledge of the professionals, which ends up also influencing the knowledge about the cost of implementation of photovoltaic technology, which has been decreasing in recent years, or even about the possibilities brought by the new solutions integrated into buildings, the BIPV modules. The broadening of the knowledge of architects and urban planners, both about BIPV-type photovoltaic modules and about the principles of active solar architecture, involves the incorporation of this theme into the curricula of undergraduate courses in Architecture and Urbanism; the confronting of the challenge of ensuring access to quality complementary and continuing training; as well as a more efficient strategy for disseminating solar photovoltaic technology by the Brazilian market, which reaches the professionals in the field of architecture and urbanism.

The research findings reinforce the need (i) to implement public policies to encourage training and the expansion of solar photovoltaic energy; (ii) for greater articulation between the productive sector and architects and urban planners – for their strategic role in the production of the built environment and in confronting the climate crisis, as well as in reducing electricity consumption in urban areas –; and (iii) to carry out informative campaigns directed at professionals in the field of architecture and urbanism, but also at civil society in general.

Based on the results achieved and the gaps perceived, new research possibilities can be envisaged, arising from various aspects related to the adoption of solar photovoltaic technology not contemplated by the research that underpins this article. In this sense, the development of future works is suggested that address the following themes: analysis of the technical and financial feasibility for the preparation of projects incorporating BIPV, considering the characteristics and use of the building and the purchasing power of the client; challenges and potential for the use of BIPV photovoltaic modules in HIS, in public housing provision programmes, such as the federal government's Minha Casa Minha Vida, with a focus on the design possibilities and cost of the solutions; and a comparative study of public policies to encourage solar photovoltaic energy in Brazil and in international contexts.

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THE EVIDENTIARY CHALLENGES IN CHARACTERIZING GENDER QUOTA FRAUD BEFORE THE TRE-GO (2022–2025)

OS DESAFIOS PROBATÓRIOS NA CARACTERIZAÇÃO DA FRAUDE À COTA DE GÊNERO NO ÂMBITO DO TRE-GO (2022–2025)

LOS DESAFÍOS PROBATORIOS EN LA CARACTERIZACIÓN DEL FRAUDE A LA CUOTA DE GÉNERO EN EL ÁMBITO DEL TRE-GO (2022–2025)

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ABSTRACT

This article investigates the evidentiary challenges in characterizing gender quota fraud before the Regional Electoral Court of Goiás (TRE-GO) between 2022 and 2025, in light of TSE Súmula nº 73 and TSE Resolution nº 23.735/2024. It argues that the deliberately open wording of these norms, combined with the structurally circumstantial nature of the evidence and the material inequalities affecting women's political participation, shifts the decisional center to judicial evaluation and renders the individualized analysis of female candidacies unavoidable. The research adopts a descriptive-analytical and exploratory approach, combining the historical-normative reconstruction of the quota policy and the jurisprudential trajectory of the TSE (from the Valença/PI and Jacobina/BA precedents to the consolidation of the evidentiary model) with the observation of four paradigmatic TRE-GO rulings, taken as empirical references showing how factually similar cases lead to opposite outcomes due to the centrality of the inferential articulation among indicia. It defends understanding fraud as an inferential illicit act, proposes the analytical category of gender procedural violence, and formulates a three-axis interpretive model: qualified evidentiary convergence, centrality of individualized analysis, and rigor in making the inferential path explicit. It concludes that the evidentiary challenges are not contingent but structural, and that the institutionally adequate response lies not in rigid standardization of criteria, but in enhancing the inferential rationality of the decision.

Keywords: Gender Quota. Fraud. Circumstantial Evidence. Individualized Analysis. Electoral Justice.

RESUMO

O artigo investiga os desafios probatórios na caracterização da fraude à cota de gênero no âmbito do Tribunal Regional Eleitoral de Goiás (TRE-GO), entre 2022 e 2025, à luz do enunciado nº 73 da Súmula do TSE e da Resolução TSE nº 23.735/2024. Sustenta-se que a redação deliberadamente aberta dessas normas, somada à natureza estruturalmente indiciária da prova e às desigualdades materiais que afetam a participação política das mulheres, desloca o centro decisório para a valoração judicial e torna inevitável a análise individualizada das candidaturas femininas. A pesquisa adota abordagem descritivo-analítica e exploratória, articulando a reconstrução histórico-normativa da política de cotas e a trajetória jurisprudencial do TSE (dos precedentes de Valença/PI e Jacobina/BA à consolidação do modelo probatório) com a observação de quatro julgados paradigmáticos do TRE-GO, tomados como referências empíricas que evidenciam como casos faticamente similares conduzem a desfechos opostos pela centralidade da articulação inferencial entre indícios. Defende-se a compreensão da fraude como ilícito de natureza inferencial, propõe-

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se a categoria analítica da violência processual de gênero e formula-se um modelo interpretativo de três eixos: convergência probatória qualificada, centralidade da análise individualizada e rigor na explicitação do percurso inferencial. Conclui-se que os desafios probatórios não constituem fenômeno contingente, mas resultado estrutural, e que a resposta institucionalmente adequada não reside na padronização rígida de critérios, mas no aprimoramento da racionalidade inferencial da decisão.

Palavras-chave: Cota de Gênero. Fraude. Prova Indiciária. Análise Individualizada. Justiça Eleitoral.

RESUMEN

El artículo investiga los desafíos probatorios en la caracterización del fraude a la cuota de género en el ámbito del Tribunal Regional Electoral de Goiás (TRE-GO), entre 2022 y 2025, a la luz del enunciado n° 73 de la Súmula del TSE y de la Resolución TSE n° 23.735/2024. Se sostiene que la redacción deliberadamente abierta de esas normas, sumada a la naturaleza estructuralmente indiciaria de la prueba y a las desigualdades materiales que afectan la participación política de las mujeres, desplaza el centro decisorio hacia la valoración judicial y torna inevitable el análisis individualizado de las candidaturas femeninas. La investigación adopta un enfoque descriptivo-analítico y exploratorio, articulando la reconstrucción histórico-normativa de la política de cuotas y la trayectoria jurisprudencial del TSE (de los precedentes de Valença/PI y Jacobina/BA a la consolidación del modelo probatorio) con la observación de cuatro fallos paradigmáticos del TRE-GO, tomados como referencias empíricas que evidencian cómo casos fácticamente similares conducen a desenlaces opuestos por la centralidad de la articulación inferencial entre indicios. Se defiende la comprensión del fraude como ilícito de naturaleza inferencial, se propone la categoría analítica de la violencia procesal de género y se formula un modelo interpretativo de tres ejes: convergencia probatoria cualificada, centralidad del análisis individualizado y rigor en la explicitación del recorrido inferencial. Se concluye que los desafíos probatorios no constituyen un fenómeno contingente, sino un resultado estructural, y que la respuesta institucionalmente adecuada no reside en la estandarización rígida de criterios, sino en el perfeccionamiento de la racionalidad inferencial de la decisión.

Palabras clave: Cuota de Género. Fraude. Prueba Indiciaria. Análisis Individualizado. Justicia Electoral.

1 INTRODUCTION

Women's political participation in Brazil remains crossed by structural asymmetries, even after the 1988 Constitution affirmed substantive equality as a foundation of the democratic order. Such asymmetries manifest themselves not only in women's numerical under-representation in elective offices, but also (and in a particularly sensitive way) in the manner in which the legal system interprets, produces and evaluates evidence when called upon to intervene in disputes related to gender policy.

The barriers to women's participation do not arise from episodic factors or individual inadequacies, but from structural devices that condition women's access to party structures, campaign resources, political visibility and, consequently, real conditions of competitiveness. This backdrop influences not only the political-electoral process, but the litigation itself, especially in the sensitive field of actions discussing gender quota fraud.

The quota policy provided for in Article 10, § 3, of Law nº 9.504/1997² has consolidated itself as one of the most relevant instruments of affirmative action in Brazilian Electoral Law, aimed not only at ensuring the formal presence of women on proportional slates, but at promoting their effective inclusion in the democratic process. The normative consolidation of the quota was accompanied, however, by a paradoxical phenomenon: the proliferation of fictitious female candidacies and the growth of Electoral Judicial Investigation Actions (AIJE) grounded in the allegation of quota fraud.

In various contexts, the AIJE ceased to be merely an instrument for safeguarding the normality of the election and became a strategic mechanism for the global challenge of proportional slates, with a direct impact on altering the result.

From this emerges the central problem of this investigation: the difficulty of establishing evidentiary criteria that are sufficiently dense and coherent to distinguish structural fraud from those situations in which real female candidacies (even if weakened by material inequalities) end up improperly classified as fictitious. This grey zone produces symmetrical risks: on the one hand, unjust revocations of legitimately won mandates; on the other, the improper maintenance of Statements of Regularity of Party Acts (DRAP), even in the face of practices that empty the purpose of affirmative policy.

The very unfeasibility of a rigid standardization of the evidentiary analysis thus constitutes the structuring axis of the problem: recent experience demonstrates that quota fraud is not revealed by a single isolated element, nor does it admit automatic solutions or replicable decision-making models.

²BRAZIL. Law No. 9,504, of September 30, 1997. Art. 10, § 3: "Of the number of seats resulting from the rules provided for in this article, each party or coalition must reserve a minimum of thirty percent and a maximum of seventy percent for candidacies of each sex."

This methodological choice imposes a relevant consequence: the need to examine gender quota fraud not only as an abstract legal category, but as a concrete decisional phenomenon, produced within specific judicial proceedings, from incomplete evidence, fragmented indicia and competing narratives. The analysis of the evidentiary challenge, therefore, is not to be confused with the dogmatic reconstruction of the institute, but with the critical observation of how the law operates when called upon to decide under conditions of uncertainty.

The specific scope of the work does not examine the normative requirements of Súmula nº 73 or of Resolution nº 23.735/2024 as abstract commands, nor does it discuss their validity or legitimacy; the central object consists in understanding how, in jurisdictional practice, the occurrence of fraud is proven, what challenges are faced by the Electoral Justice and how normative indeterminacy (expressed in formulas such as “when the facts and circumstances of the concrete case so permit the conclusion”) impacts the coherence, predictability and justice of decisions.

At the international level, the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW)³, the Convention of Belém do Pará⁴, the Beijing Platform for Action (1995) and Sustainable Development Goal (ODS) nº 5 of the 2030 Agenda reinforce that women's political participation does not constitute a mere programmatic aspiration, but an international legal obligation. At the jurisprudential level, the response of the Superior Electoral Court (TSE) culminated in the consolidation of an evidentiary model of a circumstantial nature, systematized in enunciado nº 73 of that court's Súmula⁵, whose deliberately open wording transfers the decisional center to judicial evaluation.

This choice is deepened by TSE Resolution nº 23.735/2024⁶, which dispenses with the demonstration of the subjective element (*consilium fraudis*), definitively shifting the focus to the objective-evidentiary plane.

The following problem is thus formulated: in what way do the evidentiary challenges in ascertaining gender quota fraud, in light of enunciado nº 73 and of TSE Resolution nº 23.735/2024, influence the jurisprudence of the TRE-GO, being able to lead both to unjust revocations and to the improper maintenance of DRAP, rendering the individualized analysis

³CEDAW, Convention on the Elimination of All Forms of Discrimination against Women, adopted on Dec. 18, 1979. Promulgated in Brazil by Decree No. 4,377, of September 13, 2002, art. 1.

⁴BRAZIL. Decree No. 1,973, of August 1, 1996. Promulgates the Inter-American Convention on the Prevention, Punishment and Eradication of Violence against Women (Convention of Belém do Pará), arts. 1 and 7.

⁵BRAZIL. TSE. Precedent No. 73: “Fraud against the gender quota occurs when, given the factual and circumstantial elements of the specific case, the distortion of the purpose of the rule provided for in art. 10, § 3, of Law No. 9,504/1997 is evidenced.” Approved in the plenary session of May 24, 2022.

⁶BRAZIL. TSE. Resolution No. 23,735, of February 27, 2024, art. 8, § 4: “For the characterization of fraud against the gender quota, the distortion of the purpose of the rule is sufficient, and the demonstration of the subjective element is dispensable.”

of female candidacies unavoidable? The central hypothesis is that the factual diversity of cases, the circumstantial nature of the evidence and the normative choice for open concepts prevent the consolidation of standardized criteria, leading the TRE-GO to decide on the basis of contextual reconstructions which, although they promote material justice, increase the risk of dissonant decisions and of strategic instrumentalization of AIJE.

The general objective is to analyse how these challenges impact regional jurisprudence in the period from 2022 to 2025, highlighting the limits of decisional standardization and the centrality of individualized analysis.

Methodologically, a descriptive-analytical and exploratory approach is adopted. The normative and jurisprudential reconstruction is compared with four rulings of the TRE-GO relating to the 2024 municipal elections, Campos Belos, Nerópolis, Aparecida de Goiânia and Goianira⁷, here taken not as an object of exhaustive description, but as empirical references that illustrate the central thesis. The selection is justified by a methodological trait: the first two were judged in the same plenary session, under an identical collegiate composition; the last two, already under the validity of the Resolution and under the action of a single rapporteur. This identity of conditions neutralizes external variables and isolates the evaluation of the evidence as the determining factor.

It is recorded, with epistemological transparency, that the researcher's activity in the Electoral Justice during the period demanded permanent methodological vigilance, a stance of *participant objectivation*, the research having been developed exclusively from an academic perspective, without reproduction of votes or judgments of correctness of the decisions. Far from compromising the work, this dual insertion is assumed as an explicit epistemological datum: proximity to the object, when submitted to rigorous methodological control, offers qualified access to the concrete dynamics of the formation of judicial conviction, provided it is accompanied by the deliberate refusal of any pretension to validate or invalidate the decisions examined.

The object of the analysis is not the correctness of the rulings, but the structure of the evidentiary reasoning manifested in them.

2 STRUCTURAL EXCLUSION AND THE QUOTA POLICY AS AN INSTITUTIONAL RESPONSE

The analysis of gender policy in Electoral Law presupposes the understanding that women's under-representation does not constitute a contingent or accidental phenomenon, but the result of a long, structural and institutionally reproduced historical process (Pateman,

⁷BRAZIL. TRE-GO. Electoral Judicial Investigation Action No. 0600639-47.2024.6.09.0105 (Campos Belos/GO); Electoral Appeal No. 0600797-61.2024.6.09.0054 (Nerópolis/GO); Electoral Judicial Investigation Action No. 0600544-33.2024.6.09.0132 (Aparecida de Goiânia/GO); and Electoral Judicial Investigation Action No. 0600937-51.2024.6.09.0101 (Goianira/GO). 2024 municipal elections.

1988). The construction of liberal constitutionalism, frequently presented as the foundational milestone of legal equality, operated, in practice, through a profound cleavage between the public space and the private space, consolidating a sexual division of power according to which politics and collective representation were historically associated with the masculine universe.

The feminist theory of the social contract offers a decisive analytical instrument: the modern political pact, although formulated under a universalist promise, was erected upon a “sexual contract” that confined women to the private space and reserved to men the legitimate exercise of public authority. That is why the conquest of suffrage, although fundamental, did not immediately break with the patterns of exclusion: the formal entry of women into the electorate did not automatically translate into their effective incorporation into decision-making spaces, with the systematic difficulty of transforming candidacies into viable political projects persisting.

The finding that formal equality does not promote substantive inclusion led, from the second half of the twentieth century, to the consolidation of an international normative framework. CEDAW (1979) breaks with the merely formal conception of equality by recognizing, in its Article 4, that special measures of a temporary character aimed at accelerating de facto equality do not constitute discrimination, legally legitimizing affirmative action policies, and by imposing, in its Article 7, the state duty to ensure conditions of equality in the right to vote, to be voted for and to hold public office.

The incorporation of the Convention into the Brazilian legal order, with supralegal status⁸, expands the normative density of gender policies. This movement is deepened by the Convention of Belém do Pará (1994), which reaches institutional and structural practices of violence, and by the Beijing Platform for Action (1995), which affirms that the full participation of women is an essential condition of democracy. This normative body operates a paradigmatic transition: from the paradigm of formal equality (which is satisfied with the removal of explicit legal barriers) to that of substantive equality, which recognizes inequality as a product of institutional structures and imposes upon the State the positive duty to correct it.

Within this framework, it is understood that the gender quota policy is not situated only in the plane of electoral engineering, but in the broader field of human rights and substantive democracy.

The data confirm the persistence of the deficit: according to the IPU (2025), women occupied 11.3% of parliamentary seats worldwide on the eve of Beijing, a percentage that

⁸BRAZIL. STF. RE 466,343/SP. Reporting Justice: Cezar Peluso. Judged on Dec. 3, 2008. Recognized supralegal status to international human rights treaties not approved under the terms of art. 5, § 3, of the Federal Constitution.

reached 27.2% in 2025, expressive growth, but far from parity. Comparative analysis reveals profound regional asymmetries: Latin American countries that combined robust legal quotas, rigorous oversight and effective sanctions, such as Argentina, México and Bolívia, advanced from a policy of minimum quotas to models of parity, reaching percentages close to or above 45% (Piatti-Crocker, 2019).

In contrast, democracies with fragmented, personalist or low-institutionalization party systems tend to convert the quota into a mere numerical increase of registrations, without corresponding growth in the number of women elected. These cases demonstrate that affirmative action, when conceived as a consistent public policy and protected against mechanisms of neutralization, is capable of producing substantive results; when inserted into an environment resistant to internal democratization, it tends to be captured.

In Brazil, the incorporation of gender policy occurred in a belated, gradual and reactive manner. The formation of the national political system reproduced, in a particularly intense way, the patriarchal patterns inherited from European liberal constitutionalism, combined with local specificities such as the concentration of power in the parties, political personalism and the low institutionalization of party structures.

Unlike countries that advanced through constitutional reforms or explicit political pacts in favour of parity, Brazil entered the theme in a fragmented manner, with successive legislative changes that sought to confront under-representation without profoundly altering the internal dynamics of the parties. Law nº 9.100/1995 provided for a facultative reservation of seats and, in the absence of sanctions, proved innocuous; Law nº 9.504/1997 raised the percentage to 30%, but maintained ambiguity by employing the verb “to reserve”; only Law nº 12.034/2009⁹ promoted a qualitative change, by replacing reservation with mandatory fulfilment.

This inflection triggered adaptive reactions: there was an expressive increase in registered female candidacies without proportional growth in women elected; in 2018, although women represented more than 30% of candidacies for the Chamber of Deputies, only about 15% of seats were occupied by female parliamentarians, despite women constituting approximately 53% of the electorate. Jurimetric surveys identified, in the 2020 elections, more than 1,600 proceedings related to quota fraud (UFG, 2024), and comparative studies of the G20 place Brazil among the economies with the lowest female participation in spaces of power (IBGE, 2024).

Under-representation, therefore, does not arise from the absence of rules, but from the insufficiency of mechanisms capable of ensuring their material effectiveness, which led to the

⁹BRAZIL. Law No. 12,034, of September 29, 2009. Replaces the logic of “reservation” with the mandatory filling of the minimum percentage of candidacies of each sex, making the approval of the DRAP conditional on its fulfilment.

progressive displacement of the centre of gravity of the protection of affirmative action to the Electoral Justice.

The gender quota is not a simple technique of arithmetic correction, but an instrument aimed at confronting structural inequalities reproduced within the political system. Its introduction does not eliminate the structures of exclusion; on the contrary, these reorganize themselves, producing new forms of neutralization. It is at this point that the connection with the notion of institutional political violence is established: the instrumentalization of female candidacies (registered only to fulfil formalities, without real support or intention to compete) is inserted into this category.

Law nº 14.192/2021¹⁰ consolidates this understanding: although it does not expressly typify quota fraud, its conceptual framework is compatible with the reading that fictitious candidacies constitute institutional violence, since they use women as bureaucratic instruments for the preservation of masculine structures of power (Laena, 2023).

The symbolic dimension is central to this analysis. Affirmative action communicates to society that women must occupy decision-making spaces and that their participation is a condition of democratic legitimacy; when captured by practices of simulation, the symbolic effect is inverted: instead of promoting inclusion, it reinforces stereotypes of incapacity, disinterest or inadequacy of women to politics. The literature points out that fictitious candidacies transmit the social message that women are not suited to politics, perpetuating exclusionary imaginaries and discouraging future female participation (Laena, 2023).

The dimension is, moreover, intersectional, insofar as Black, peripheral, indigenous women and members of historically marginalized groups are the most vulnerable to party instrumentalization, since they have less institutional protection and less capacity for internal contestation (Crenshaw, 1989). From this arises a relevant implication for the Electoral Justice: the reading that treats fictitious female candidates as authors of the illicit act is rejected, recognizing them, in many cases, as victims, and an evidentiary approach sensitive to structural asymmetries is required, avoiding automatic presumptions that may re-victimize women who effectively attempted to participate in the contest.

The requirement of individualized analysis of female candidacies fulfils, within this framework, a dual and essential function. On the one hand, it protects women who effectively participated in the contest, preventing real campaigns from being confused with artificial arrangements and authentic candidates from being penalized by generalizing patterns. On the other, it prevents the legitimization of merely formal candidacies, instrumentalized by the parties to fulfil legal requirements without any intention of promoting substantive inclusion. It is

¹⁰BRAZIL. Law No. 14,192, of August 4, 2021, art. 3. Defines political violence against women as any action, conduct or omission whose purpose is to prevent, hinder or restrict the exercise of their political rights.

a mechanism that seeks to balance the protection of affirmative action with the preservation of legal certainty, recognizing the evidentiary complexity inherent in structural illicit acts.

It is precisely this balance that the following chapter examines, by reconstructing the trajectory through which the superior Electoral Justice built the evidentiary criteria intended to confront fraud without compromising the protection of the women whom gender policy seeks to benefit.

It is also important to emphasize that gender quota fraud emerges not as a punctual anomaly, but as an adaptive strategy for the reproduction of power. Each normative advance (the obligation of fulfilment, the allocation of campaign fund resources, the control of financial movement) was followed by new forms of neutralization, more sophisticated and dissimulated. This adaptive character is decisive for the understanding of the evidentiary challenge: as fraudulent practices become less explicit, direct evidence becomes progressively rarer, and the weight of circumstantial inference more central.

The very evolution of the phenomenon pushes the legal system towards the terrain of contextual evaluation, in which the distinction between the instrumentalized candidacy and the weakened candidacy becomes ever more subtle, and, for that very reason, ever more dependent on the quality of the evidentiary reasoning mobilized by the judge.

3 THE JURISPRUDENTIAL CONSTRUCTION OF THE EVIDENTIARY MODEL IN THE TSE

The evidentiary model in force derives from a progressive hermeneutic construction. The *leading case* of Valença do Piauí¹¹ revealed the architecture of fictitious candidacies: all the investigated candidates presented an absolute absence of campaign acts, empty or symbolic accountability, null or negligible votes and (a decisive datum) direct kinship ties with male candidates of their own coalitions. The objective analysis of the case records demonstrated that, disregarding the fictitious candidacies, the male slates became numerically unviable, evidencing that the fraud was not peripheral, but structural.

The extreme similarity of the accountability reports (values, dates and numerical sequence of the invoices) denoted accounting make-up, demonstrating that the Court relied not only on the absence of a campaign, but on documentary evidence of the fabrication of a basis. The TSE established that the requirement of robust and unequivocal evidence is not to be confused with direct evidence, fraud normally being constructed from a set of convergent indicia, and that, once recognized, the revocation of the registrations and diplomas of all

¹¹BRAZIL. TSE. Special Electoral Appeal No. 0000193-92.2016.6.18.0018 (Valença/PI). Reporting Justice: Jorge Mussi. Judged on Sept. 17, 2019.

candidates linked to the DRAP is imposed, since it is a defect of origin, while the accountability of party leaders without proof of participation is however excluded¹².

Valença/PI thus established the fundamental coordinates of the hermeneutics of fraud (Targino; Sampaio Júnior, 2020).

The Jacobina/BA case¹³ refined these criteria in the face of a more complex and less explicit evidentiary set. In Jacobina, the fraud was not presented in a clean and homogeneous form, but through nuances and dissimulations, attempts to simulate minimal campaign acts, generic declarations of support and, in one of the testimonies, the acknowledgement that the investigated party was unaware of being registered as a candidate, a situation that exemplifies what feminist theory calls “candidacy as a borrowed body”.

In reforming the regional decision, which had adopted a restrictive understanding of robust evidence, the TSE reaffirmed that this does not require positive certainty, but a coherent, convergent and contextual set of indicia, evaluated as a whole; and that minimal campaign acts, when isolated or devoid of organicity, do not exclude the possibility of fraud. The model of “circumstantial robustness” was consolidated, according to which the manipulation of the quota may assume hybrid forms, with candidacies that appear to have some movement, but whose essence remains instrumental.

One aspect of these precedents projects directly onto the evidentiary challenge: the extent of the sanctions. The jurisprudence consolidated from Valença/PI admits the revocation of the entire proportional slate, regardless of the demonstration of direct participation of all candidates, on the grounds of the structural nature of the illicit act, the defect of origin contaminates the slate as a whole, imposing the nullity of votes and the recounting of the electoral quotient.

This model of expanded accountability, although coherent with the understanding of fraud as a systemic phenomenon, may imply relevant tensions with due process of law and with the principle of subjective responsibility, especially when it reaches female candidacies that did not participate in the fraud and that, in many cases, were victims of it (Cunha; Bastos Junior, 2020). The severity of the consequences raises, in turn, the level of evidentiary requirement: the more serious the effects of the recognition of the illicit act, the more rigorous must be the demonstration of its occurrence, which reinforces the centrality of the standard of robust and convergent evidence and the caution imposed by the principle *in dubio pro suffragio*.

¹²BRAZIL. TSE. Precedent No. 24: “A party leader who acted within the limits of his legal and statutory duties is not a legitimate defendant in an electoral judicial investigation action.”

¹³BRAZIL. TSE. Interlocutory Appeal in the Interlocutory Appeal in Special Electoral Appeal No. 0600651-94.2020.6.05.0046 (Jacobina/BA). Justice responsible for the ruling: Alexandre de Moraes. Judged in 2021.

This jurisprudential accumulation culminated in enunciado nº 73, which systematized the understanding that fraud may be recognized on the basis of grave, precise and convergent indicia, evaluated as a whole and not in isolation. The enunciado did not arise suddenly: it resulted from a long trajectory marked by divergent decisions among the Regional Courts, some requiring direct evidence of fraudulent intent, others recognizing fraud only from the absence of a campaign, others still admitting circumstantial evidence without clarity as to the degree of robustness required.

In the face of this heterogeneous scenario, and after the accumulation of reiterated and uniform decisions, the TSE opted for the issuance of a *súmula* as an instrument of stabilization of expectations and of reduction of decisional fragmentation. Two recurrent formulations in the Court's debates condense its epistemology: fictitious candidacies leave no confessions, but traces, it being incumbent upon the Electoral Justice to interpret them; and robust evidence cannot be confused with impossible evidence, under penalty of transforming affirmative action into a dead letter.

The enunciado thus consecrates the recognition that substantive equality policies require sophisticated interpretive mechanisms, capable of identifying dissimulations and minimal simulations of a campaign, and that fraud should not be analysed from the perspective of subjective culpability, but as a structural dynamic that distorts electoral competition.

TSE Resolution nº 23.735/2024, by positivizing circumstantial criteria (Article 8, §§ 2 to 5) and dispensing with the subjective element (Article 8, § 4), conferred greater predictability as to the admissible elements, without eliminating the centrality of inferential evaluation: the positivization began to operate as a formally structured analytical matrix, requiring from the judge a corresponding argumentative burden as to the articulation among the indicia. The dispensing with the subjective element by instruction raises a still-open question as to the limits of the regulatory power in light of Article 105 of Law nº 9.504/1997, deserving its own doctrinal treatment;

on the empirical plane, however, this controversy proves secondary, since the evidentiary structure remains the same, with or without the subjective element, because the evaluation invariably depends on the inferential articulation of the indicia. The coexistence of the enunciado and the resolution established, in synthesis, a coherent regulatory model, in which the standard of robust and convergent evidence operates as an epistemological filter against precipitate inferences, without the positivization of the criteria having modified the fundamental logic of the decision: the presence or absence of inferential articulation among the indicia continues to be the decisive point.

This normative arrangement is articulated with a principle of restraint that permeates the entire matter: the *in dubio pro suffragio*. In actions of a sanctioning nature, in which the gravity of the consequences (revocation of registrations, diplomas and mandates, nullity of votes and recalculation of the quotient) imposes rigour in the demonstration of the facts, evidentiary doubt is not supplied by presumption, but resolved in favour of the preservation of the electoral result.

This principle is not a mere tie-breaking rule, but a structuring criterion of evaluation: it recognizes that the error of condemning an authentic candidacy as fictitious and the error of acquitting a real fraud are not symmetrical in their democratic consequences, and it establishes, in the face of irreducible uncertainty, a preference for popular sovereignty. The articulation between the requirement of robust evidence and the *in dubio pro suffragio* thus composes the framework within which the judge exercises inferential evaluation, a framework that delimits, without eliminating, the margin of indeterminacy inherent in the illicit act.

4 THE EVIDENTIARY CHALLENGES IN REGIONAL APPLICATION: EVIDENCE AS THE DECISIONAL CENTRE

The preceding normative and jurisprudential reconstruction provides the framework from which the concrete application of the evidentiary model by the TRE-GO is observed. It is not intended here to provide an exhaustive description of the case records, but to mobilize four rulings as empirical references that illuminate the central thesis: that the evidentiary challenge, far from constituting an episodic difficulty, is a structural element of the model itself. The analytical value of these rulings resides less in their individual content than in their comparative arrangement, particularly in the fact that pairs of factually analogous cases, judged under identical institutional conditions, led to opposite outcomes.

It is this controlled asymmetry that allows the evaluation of the evidence, and not the norm, to be isolated as the determining variable.

The observation of the four TRE-GO rulings confirms that the evidentiary challenge is not contingent, but structural. The most eloquent trait of the sample is methodological: factually analogous cases, judged under an identical normative framework, led to opposite outcomes, and the divergence is not located in the plane of the facts, but in the manner in which the evidence is interpreted. Campos Belos and Nerópolis, judged in the same plenary session and by the same collegiate composition, shared a similar factual basis: female candidacies with reduced voting, limited financial movement and absence of an ostensible campaign.

In Campos Belos, the convergence of these negative indicia sustained the inference of fraud, with the sentence recognizing the non-existence of “minimally identifiable electoral protagonism”; in Nerópolis, the same elements were interpreted as ambiguous data, and the existence of disclosure on social networks, campaign materials and movement compatible with the candidate's reality led to dismissal, reinforced by an intra-list comparative criterion, precariousness was not exclusive to the challenged candidate, but a structural characteristic of the group. The contrast, between two cases decided in the same collegiate body, isolates the evaluation of the evidence as the determining variable (Streck, 2011).

Aparecida de Goiânia and Goianira, judged already under Resolution nº 23.735/2024 and by the same rapporteur, confirm the diagnosis in a qualitatively distinct key. In Aparecida de Goiânia, the evidentiary configuration was complex; alongside the usual indicia, the absence of electoral quittance and the explicit support for another candidate stood out, a datum that shifted the axis of the analysis from the absence of one's own campaign to deviated political action. The decisive distinction emerged between the fictitious candidacy, which presupposes the non-existence of intention to compete, and the unviable candidacy, formally registered but without material conditions of viability;

the *ratio decidendi* consolidated that the formal fulfilment of the quota does not inhibit the material examination, but the characterization of fraud requires robust and convergent evidence of the finalistic distortion, unviability not being confused with simulation. In Goianira, the indicia admitted a plausible alternative explanation: the finding of a tacit withdrawal, arising from a supervening loss of political support, explained in a non-fraudulent way the low intensity of the electoral acts.

This category, although not provided for in the positivized list, fulfilled a function analogous to that of an open exception clause, revealing that the positivization of the indicia does not close the system, since it always admits unforeseen hypotheses that operate as competing explanations.

The joint reading of the four rulings authorizes two findings. The first is that two modalities of evidentiary insufficiency are distinguished: a quantitative one (as in Nerópolis, due to the absence of positive elements evidencing the distortion) and a qualitative one, as in Goianira, due to the existence of an alternative explanation for the same elements. The second, more profound, is that the determining variable is not the norm, but the quality of the inferential construction: the positivization of the criteria conferred certainty as to the admissible elements, but did not reduce the zones of indeterminacy.

In all cases, the application of the principle *in dubio pro suffragio* operated as a mechanism for the resolution of uncertainty, resolving the doubt in favour of the preservation

of the electoral result. The problem of gender quota fraud, on the evidentiary plane, is not one of a catalogue of indicia, but of articulation among them; fraud is not defined by the presence of certain elements, but by the manner in which those elements are articulated, so that the decisive distinction operates between evidentiary convergence and ambiguity, and not between the presence and absence of evidence.

The stability of the criteria affirmed by the TRE-GO, added to the variability of the results, does not represent inconsistency. On the contrary, it expresses the judge's fidelity to the model of individualized analysis, in consonance with the duty of uniformization, stability, integrity and coherence of jurisprudence (Article 926 of the Code of Civil Procedure).

Decisional divergence, seen from this angle, is a datum of coherence, and not of incoherence, of the evidentiary system: it confirms that gender quota fraud is, in the final analysis, an inferential construction dependent on the judicial evaluation of the evidence, and that the institutionally adequate response does not consist in the rigid standardization of criteria, but in the qualification of the reasoning that articulates the indicia.

The observation of the rulings allows the systematization of the structural evidentiary challenges that cross the matter. The first is the predominance of circumstantial evidence: none of the cases presents direct evidence of collusion or deliberate simulation, the imputation being structured from accountability, electoral results and the absence of campaign records, interpreted in light of the circumstances.

The second is the centrality of the proof of a negative fact: fraud is frequently constructed as an omission, the non-performance of a campaign, the non-obtaining of votes, the non-existence of relevant financial movement, which shifts the centre of the evidence to the absence of expected behaviour and raises the delicate question of knowing when the absence of a datum can validly sustain the inference of an illicit act. The third is the presence of implicit presumptions: in certain decisional arrangements, the absence of expected electoral behaviour brings the reasoning close to a logic of reversal of the burden of proof, which the requirement of robust and convergent evidence seeks to contain.

The fourth is the structural ambiguity of the indicia: unexpressive voting, low movement and limited campaign are not, in themselves, univocal indicators of fraud, admitting alternative explanations (unviable candidacy, tacit withdrawal, fragility shared by the list) which, when plausible, prevent the stabilization of the fraudulent inference.

These challenges are neither contingent nor arise from specific failures in the conduct of the proceedings; they reveal structural limitations of the normative and jurisprudential model itself. The combination of open normative concepts, predominantly circumstantial evidence and material inequalities that affect the competitiveness of female candidacies

necessarily produces zones of indeterminacy in the evidentiary standard. The absence of objective criteria to distinguish fictitious candidacies from low-competitiveness candidacies confers upon the judge a wide margin of evaluation, which may result in divergent decisions even in factually similar situations.

The central challenge, therefore, lies not only in identifying fraud, but in defining the criteria by which it may be validly recognized, and it is at this point that the contribution of the study is inserted: by evidencing the variability of the evidentiary standard, it is demonstrated that the consolidation of jurisprudence depends not only on the setting of abstract parameters, but on the construction of more precise criteria of evaluation of the evidence, capable of reducing uncertainty and conferring greater predictability on decisions.

The picture that emerges from the regional observation is, therefore, that of an evidentiary standard under construction. The combined application of enunciado nº 73 and of Resolution nº 23.735/2024 did not eliminate the need for critical judgment on the evidence; on the contrary, it reinforced the centrality of the judge's interpretive activity. The manner in which the inference is carried out (more or less demanding, more or less open) determines the outcome of the proceeding, evidencing that the problem does not reside in the normative definition of fraud, but in its demonstration.

Hence the thesis that articulates the entire work and responds directly to the title: the evidentiary challenges in the characterization of gender quota fraud are structural, and their overcoming does not pass through the rigid standardization of criteria, incompatible with the nature of the phenomenon, but through the qualification of the inferential path that leads from the indicia to the conclusion, the only path methodologically compatible with the complexity of the object and with the requirements of a procedurally just decision.

5 EVIDENCE, DECISION AND DEMOCRATIC TENSION: FRAUD AS AN INFERENTIAL ILLICIT ACT

The findings shift the problem to the plane of the theory of evidence. Gender quota fraud is not a fact that is discovered, but a meaning that is constructed: it is in the articulation among indicia, inferences and decisions that its legal existence is defined. The decision does not derive automatically from the facts, but from the manner in which these are organized, interpreted and integrated into a legally justifiable narrative, a domain in which the distinction between fact and interpretation becomes particularly tenuous, requiring argumentative rigour and methodological control of the inferences (Taruffo).

Fraud is thus situated in a zone of intersection between law and epistemology, in which the sufficiency of the evidence depends not only on its existence, but on its capacity to sustain

a stable and convergent inference. This finding dialogues with the warning that the uncritical transposition of the notion of fraud against the law to the electoral field may produce excessively open categories, capable of encompassing situations that correspond not to fraudulent practices, but to manifestations of structural fragility of the candidacies (Andrade Neto; Gresta; Santos, 2018).

The use of circumstantial evidence requires not only the identification of the facts, but the making explicit of the reasons why these facts are considered sufficient to sustain the adopted conclusion. The absence of this making explicit compromises the transparency and controllability of the decision, transferring to the inner forum of the judge an operation that should be intersubjectively verifiable. It is precisely at this point that the problem of gender quota fraud approaches the contemporary discussions of the theory of evidence: the judgment of sufficiency is not given, but constructed, and its legitimacy depends on the quality of the justification that accompanies it.

Uncertainty, in a normative environment structured by open clauses, is not eliminated, but managed, and the judge acts as an operator of reduction of this uncertainty, whose decision not only applies the norm, but constructs the very object of the judgment from the available evidence. Decisional variability must therefore be interpreted not as inconsistency, but as an expression of the epistemic limits of circumstantial evidence.

The structural difficulty of producing proof of a negative fact requires caution in the distribution of the burden of proof. The construction of fraud from the absence of behaviour (non-performance of a campaign, non-obtaining of votes, non-existence of relevant financial movement) tends to implicitly shift the burden to the investigated candidate, urged to demonstrate the authenticity of her own participation (Costa, 2025). By requiring from the candidates the reiterated proof of their political legitimacy, the system may institute a more rigorous validation standard for women than for men, configuring what is here termed, in analytical terms, *gender procedural violence*.

This is not a rhetorical judgment, but a conceptual instrument intended to illuminate the symbolic and material dimension of the disproportionate argumentative burden that falls upon female candidates in quota fraud actions, reproducing, on the jurisdictional plane, the same asymmetries that the quota policy seeks to overcome. The category does not exhaust the theme, but offers a useful reading key for future empirical research on the distribution of the burden of proof and the differentiated procedural treatment of male and female candidacies of low competitiveness.

This dynamic requires distinguishing, with clarity, two planes frequently confused in decisional practice. One is that of the electoral unviability of the candidacy (a material

phenomenon, linked to the adverse conditions of competition that structurally characterize female participation; the other is that of fraudulent simulation) an intentional phenomenon, linked to the finalistic distortion of the norm. The weakened candidacy is not, in itself, a fictitious candidacy: to confuse them means to punish fragility as if it were fraud, transferring to the jurisdictional plane precisely the inequalities that affirmative action intends to correct.

The requirement of robust and convergent evidence functions, in this sense, as an epistemological filter that prevents the inference of fraud from indicia of low explanatory density, protecting the authentic candidate without, however, legitimizing the merely formal candidacy instrumentalized by the party. The balance between these two poles (protection of affirmative action against its capture and protection of candidates against procedural re-victimization) constitutes the core of the democratic tension that the evidentiary challenge encloses.

The tension between the repression of fraud and the protection of female participation manifests itself in a sensitive way in the extent of the sanctions. The model of expanded accountability inaugurated in Valença/PI, by admitting the revocation of the entire slate regardless of the demonstration of direct participation of each candidate, may create tension with due process of law and with the principle of subjective responsibility, above all when it reaches female candidacies that did not participate in the fraud (Cunha; Bastos Junior, 2020).

The effectiveness of gender policy depends not only on the intensity of repression, but on the quality of the evidentiary standard that sustains it: the requirement of robust evidence cannot be understood as a rhetorical formula, but as an operative criterion that imposes upon the judge the duty to rigorously justify the sufficiency of the indicia.

This requirement connects the matter to the contemporary debate on sanctioning electoral law. The AIJE being an action of a sanctioning nature, whose consequences reach fundamental rights of political participation, the evidentiary standard that informs it cannot be equated with that of the mere preponderance of evidence, proper to ordinary civil procedure, but must approach a higher level of conviction, compatible with the gravity of the effects.

It is not a matter of uncritically importing the criminal standard of proof beyond reasonable doubt, inadequate to the circumstantial dynamics of structural illicit acts, but of recognizing that quota fraud is situated at an intermediate point, in which the required robustness grows in proportion to the severity of the sanction. Robust and convergent evidence functions, in this register, as the operational translation of this intermediate requirement: neither the absolute certainty, which would render affirmative action unfeasible, nor the mere plausibility, which would convert it into an instrument of persecution. The

evidentiary challenge is, in essence, the challenge of calibrating this level, a task that admits no abstract solution, but only argumentative construction case by case.

In the face of this picture, a three-axis interpretive model is proposed, aimed at the rationalization of jurisdictional activity without suppression of the complexity of the phenomenon. The first is qualified evidentiary convergence, which rejects decisions based on isolated indicia or those of low explanatory density. The second is the centrality of individualized analysis of candidacies, a technique of restraint of generalizations and stereotypes that protects both authentic candidates, preventing real campaigns from being confused with artificial arrangements, and the very purpose of affirmative action, preventing the legitimization of merely formal candidacies.

The third is rigour in making explicit the inferential path adopted by the judge, a condition of argumentative transparency and of control of the decision: it is not enough to enumerate the indicia, the demonstration of the interpretive path that confers upon them convergence and meaning is required. These parameters do not eliminate the uncertainty inherent in the phenomenon, but allow its rational management.

From this arises a practical implication for the institutional design of oversight: if the inferential structure of the evidence is the critical point, and not the catalogue of indicia, any future regulatory improvement should concentrate less on the expansion of circumstantial elements and more on the construction of parameters of articulation among them, analytical protocols, inferential standards and mechanisms of reinforced motivation of the decision. It is, in the final analysis, a matter of moving the regulatory focus from the plane of the indicia to the plane of the inference: from what is admitted as an element of evidence to how these elements should be articulated in a judgment of sufficiency.

The proposed model does not intend to close the system, but to qualify it: it recognizes that gender quota fraud will continue to challenge the legal system, precisely because it is situated in a zone of intersection between law, politics and social reality, and that what is required is not the construction of rigid criteria, but the development of a decisional practice capable of dealing with complexity without reducing it, preserving at the same time the integrity of the electoral process and the inclusive purpose of gender policy.

On the theoretical plane here developed, it can be affirmed that gender quota fraud is not a fact that is discovered, but a meaning that is constructed. It is in the articulation among indicia, inferences and decisions that its legal existence is defined, and it is in this same space that, in the final instance, not only the validity of specific candidacies but the effective reach of a public policy aimed at the transformation of the structures of power is decided. The judicial decision, in this domain, is never mere subsumption: it reconstructs the object it judges.

To recognize this nature does not weaken the control of rationality; on the contrary, it makes it possible, by making explicit that the legitimacy of the decision rests not on the illusion of a self-evident truth extracted from the case records, but on the demonstrable quality of the inferential path that leads from the indicia to the conclusion. It is this requirement of explicit inferential grounding that converts apparent discretion into controllable argumentative responsibility, a condition without which the repression of fraud and the protection of female participation cannot coexist in a democratically legitimate manner (Streck, 2011).

The three contributions proposed in this study articulate themselves, finally, into a unity. The understanding of fraud as an inferential illicit act is the diagnosis; the category of gender procedural violence is the critical warning about the risks of this diagnosis when applied without sensitivity to structural asymmetries; and the three-axis model is the propositive response that seeks to reconcile the effective repression of fraud with the protection of authentic candidacies.

None of the three in isolation exhausts the problem, but, taken together, they offer to the electoral judiciary and to legal scholarship a methodological repertoire capable of guiding the decision without reducing the phenomenon to closed formulas, a repertoire that recognizes, with realism, that uncertainty is constitutive of the object and that the task of the law is not to eliminate it, but to manage it in a transparent, controllable and procedurally just manner.

It is fitting, finally, to situate the broader democratic significance of this discussion. The manner in which the Electoral Justice resolves the evidentiary challenge of gender quota fraud is not a merely technical question: it defines, in practice, the effective reach of a public policy conceived to alter the historical structures of exclusion. An excessively permissive evidentiary standard exposes authentic female candidacies to the risk of revocation, re-victimizing women who faced, with scarce resources, the structural adversities of the contest, and producing the perverse effect of discouraging future female participation.

An excessively rigid standard, in turn, shields the practices of simulation and converts affirmative action into an empty formality. Between these two extremes, the judicial decision operates as an instance of mediation, and the quality of this mediation depends, in the final analysis, on the inferential rationality that sustains it. Evidence, in this domain, is not merely an instrument of reconstruction of the facts: it is the place where the destiny of a constitutional promise of substantive equality is decided.

6 FINAL CONSIDERATIONS

To the guiding question, the investigation responds that the evidentiary challenges in ascertaining gender quota fraud are not contingent phenomena, but the structural result of the combination of open normative concepts, predominantly circumstantial evidence and material inequalities that affect women's political participation. These factors, articulated, prevent the consolidation of standardized criteria and render the individualized analysis of candidacies not merely convenient, but a requirement of decisional rationality.

The central hypothesis was confirmed: what differentiates a favourable outcome from an unfavourable one, in cases with structurally similar indicia, is not the isolated presence of unexpressive voting, absence of a campaign or standardized accounts, but the manner in which these elements converge (or fail to converge) into a coherent and robust inferential narrative.

The research offers three contributions. On the conceptual plane, it argues that gender quota fraud is, in a strict legal sense, an illicit act of an inferential nature, whose proof is not realized by the presentation of direct evidence, but by the articulation of indicia into an evidentiary structure whose quality depends decisively on the reasoning mobilized by the judge, so that the control of the rationality of the decision requires explicit inferential grounding. On the critical plane, it proposes the analytical category of gender procedural violence as a reading key for the disproportionate argumentative burden imposed upon female candidates.

On the propositive plane, it presents the three-axis model (qualified evidentiary convergence, centrality of individualized analysis and rigour in making explicit the inferential path) as a methodological repertoire capable of guiding decisions without reducing the phenomenon to closed formulas. It should also be noted a dogmatic dimension of increasing reach: jurisprudence, in dialogue with Law n° 14.192/2021, has been consolidating the understanding that the instrumentalized candidate does not figure as the author of the fraud, but as a victim of gender political violence, a conception that tends to influence future decisional parameters.

The limitations of the scope are recorded: the spatial circumscription to the TRE-GO and the temporal one to 2022–2025, as well as the choice to observe rulings in depth to the detriment of the sample extent, restrict the generalization of the conclusions to other courts and normative frameworks. The methodological design (observation of rulings as a technique of documentary research, and not a case study in the technical sense) privileged interpretive depth, an appropriate choice for the object, but which must be made explicit as an epistemological choice.

Moreover, the academic perspective adopted is not to be confused with any judgment of correctness on the decisions examined, although the institutional position of the researcher in the period demanded permanent epistemological vigilance.

Various fronts of investigation open up from the findings. In the first place, comparative empirical studies involving different Regional Courts could test the hypothesis that the semantic openness of the evidentiary standard produces structural, and not merely conjunctural, decisional dispersion. In the second place, quantitative research on the distribution of the argumentative burden between male and female candidacies (examining, for example, the frequency with which the positive proof of campaign acts is required from the female candidate) could assess, in verifiable terms, the hypothesis of gender procedural violence.

In the third place, it is desirable to deepen the discussion on the limits of the extension of sanctions to candidates not directly involved in the fraudulent practice, in dialogue with the principle of subjective responsibility and with the contemporary debates on sanctioning electoral law. Finally, space opens up for investigations into the role of the internal instances of parties and federations in the selection of and effective support for female candidacies, in a key that articulates electoral law, political science and democratic theory.

The Electoral Justice exercises, in this field, a function of mediation between substantive equality, popular sovereignty and legal certainty. Its action cannot be reduced to the mechanical application of norms, requiring permanent interpretive reconstruction, in which evidence assumes a central and decisive role. The effectiveness of the gender quota policy depends not only on the intensity of the repression of fraud, but, perhaps above all, on the quality of the evidentiary standard that sustains it: to identify fraud is necessary; to identify it in a procedurally just manner is a condition of democratic legitimacy.

It is in this balance, demanding and permanent, that the evidentiary challenge resides that this article has sought to understand and, to the extent possible, contribute to rationalizing.

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LIST OF ABBREVIATIONS AND ACRONYMS

- **AIJE** Electoral Judicial Investigation Action
- **CEDAW** Convention on the Elimination of All Forms of Discrimination against Women
- **DRAP** Statement of Regularity of Party Acts
- **FEFC** Special Campaign Financing Fund
- **G20** Group of Twenty
- **IBGE** Brazilian Institute of Geography and Statistics
- **IPU** Inter-Parliamentary Union
- **ODS** Sustainable Development Goals
- **STF** Federal Supreme Court
- **TRE-GO** Regional Electoral Court of Goiás
- **TSE** Superior Electoral Court
- **UFG** Federal University of Goiás

FROM THE BATTLEFIELD TO THE MILITARY-TECHNOLOGICAL COMPLEX: HOW MODERNITY RECONFIGURES WAR AND NATIONAL STRATEGIES

DO CAMPO DE BATALHA AO COMPLEXO MILITAR TECNOLÓGICO: COMO A MODERNIDADE RECONFIGURA A GUERRA E AS ESTRATÉGIAS NACIONAIS

DEL CAMPO DE BATALLA AL COMPLEJO MILITAR TECNOLÓGICO: CÓMO LA MODERNIDAD RECONFIGURA LA GUERRA Y LAS ESTRATEGIAS NACIONALES



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ABSTRACT

Contemporary technological advancement has reignited the strategic debate on the transformation of war. The theses of the Revolution in Military Affairs (RMA) and Network-Centric Warfare (NCW), updated by the contemporary promise of Artificial Intelligence (AI), postulated the reduction of Clausewitzian friction and the “fog of war” through automation and data superiority. This theoretical essay investigates how technological modernity alters war and national strategies in the near future, defending the hypothesis that technology does not eliminate friction but reconfigures it. A qualitative approach is adopted, grounded in an exploratory case study on the military modernization of the Russian Federation, focusing on the State Armament Program (GPV 2020) and its performance in the War in Ukraine. The triangulation between classical and contemporary theoretical frameworks and empirical evidence demonstrates that sensor saturation generated a transparent battlefield that contributed to a return to high-friction positional warfare. This dynamic transferred the weight of tactical friction to the Defense Industrial Base (DIB) and logistics, subordinating the state to an emerging civilian “Military-Technological Complex.” As compensation for this attrition, major powers began to orchestrate other types of action to reduce the logistical burden. It is concluded that, in the 21st century, strategic advantage tends not to reside merely in automation, but in the state's capacity to govern friction in its logistical rear, integrate civil-military innovation, and dominate the informational environment amid the uncertainty of combat.

Keywords: Strategy. Friction. Defense Industrial Base. Military-Technological Complex. War in Ukraine.

RESUMO

O avanço tecnológico contemporâneo reacendeu o debate estratégico sobre a transformação da guerra. As teses da Revolução nos Assuntos Militares (RMA), da Guerra Centrada em Redes (NCW), atualizadas pela promessa contemporânea da Inteligência Artificial (IA), postularam a redução da fricção clausewitziana e do “nevoeiro da guerra” por meio da automação e da superioridade de dados. Contudo, este ensaio teórico investiga como a modernidade tecnológica altera a guerra e as estratégias nacionais no futuro próximo, defendendo a hipótese de que a tecnologia não elimina a fricção, mas a reconfigura. Adota-se uma abordagem qualitativa fundamentada em um estudo de caso exploratório sobre a modernização militar da Federação Russa, com o foco no Programa Estatal de

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Armamento (GPV 2020) e sua atuação na Guerra na Ucrânia. A triangulação entre o referencial teórico clássico e contemporâneo e as evidências empíricas demonstra que a saturação de sensores gerou um campo de batalha transparente que contribuiu para o retorno à guerra posicional de alta fricção. Essa dinâmica transferiu o peso da fricção tática para a Base Industrial de Defesa (BID) e para a logística, subordinando o Estado a um emergente “Complexo Militar-Tecnológico” civil. Como compensação a esse desgaste, as potências passaram a orquestrar outros tipos de ação para diminuir a carga logística. Conclui-se que, no século XXI, a vantagem estratégica tende a não residir apenas na mera automação, mas na capacidade estatal de governar a fricção em sua retaguarda logística, integrar a inovação civil-militar e dominar o ambiente informacional perante a incerteza do combate.

Palavras-chave: Estratégia. Fricção. Base Industrial de Defesa. Complexo Militar-Tecnológico. Guerra na Ucrânia.

RESUMEN

El avance tecnológico contemporáneo ha reavivado el debate estratégico sobre la transformación de la guerra. Las tesis de la Revolución en los Asuntos Militares (RMA) y de la Guerra Centrada en Redes (NCW), actualizadas por la promesa contemporánea de la Inteligencia Artificial (IA), postularon la reducción de la fricción clausewitziana y de la “niebla de la guerra” mediante la automatización y la superioridad de datos. Este ensayo teórico investiga cómo la modernidad tecnológica altera la guerra y las estrategias nacionales en el futuro próximo, defendiendo la hipótesis de que la tecnología no elimina la fricción, sino que la reconfigura. Se adopta un enfoque cualitativo basado en un estudio de caso exploratorio sobre la modernización militar de la Federación Rusa, con foco en el Programa Estatal de Armamento (GPV 2020) y su desempeño en la Guerra en Ucrania. La triangulación entre el marco teórico clásico y contemporáneo y las evidencias empíricas demuestra que la saturación de sensores generó un campo de batalla transparente que contribuyó al retorno a la guerra posicional de alta fricción. Esta dinámica transfirió el peso de la fricción táctica hacia la Base Industrial de Defensa (BID) y la logística, subordinando al Estado a un emergente “Complejo Militar-Tecnológico” civil. Como compensación a ese desgaste, las potencias comenzaron a orquestrar otros tipos de acción para reducir la carga logística. Se concluye que, en el siglo XXI, la ventaja estratégica tiende a no residir únicamente en la mera automatización, sino en la capacidad estatal de gobernar la fricción en su retaguarda logística, integrar la innovación civil-militar y dominar el entorno informacional ante la incertidumbre del combate.

Palabras clave: Estrategia. Fricción. Base Industrial de Defensa. Complejo Militar-Tecnológico. Guerra en Ucrania.

1 INTRODUCTION

Understanding war in the 21st century requires a rigorous theoretical framework, capable of analysing the evolution of strategic thought in the face of the allure of technological promises (Duarte, 2012). Carl von Clausewitz's theory of war remains central to this analysis, above all through his concept of friction, conceived as the fundamental element that distinguishes real war from war idealised on paper (Clausewitz, 2010). Friction encompasses uncertainty, danger, physical effort, intelligence failures and chance, forming the “fog of war” that challenges the reasoning and action of commanders on the battlefield (Clausewitz, 2010; Tavares; Ramos; Franchi, 2018).

From the 1990s onwards, the rise of the Revolution in Military Affairs (RMA) and of Network-Centric Warfare (NCW) spread the theoretical belief that technology could reduce or even eliminate this structural friction (Owens; Offley, 2000). Theorists such as Cebrowski and Garstka postulated that data fusion and network interconnection would create a situational awareness capable of guaranteeing the self-synchronisation of forces and an unrivalled speed of command (Cebrowski; Garstka, 1998). From this perspective, a “system of systems” of Command, Control, Communications, Computing and Intelligence would allow commanders to dispel the traditional fog of war (Owens; Offley, 2000). For the theorists of this strand, technological modernity would have the potential to transform combat into an essentially predictable engineering exercise, conducted from the top down (Knox; Murray, 2001).

In contemporary literature, this utopian expectation evolved from the digitisation of networks to the promise of Artificial Intelligence (AI) and full automation. It is believed, in some strategic circles, that autonomous systems could partially or entirely replace human cognitive and emotional limitations in combat (King, 2025). However, authors such as Anthony King argue that AI acts primarily as a probabilistic tool for processing large volumes of data. The efficient operation of these complex systems has been producing the rise of a new “Military-Technological Complex”, inserting civilian technology corporations directly into military operations and introducing new institutional variables into the strategies of the state (King, 2025). Critics of technological arrogance, hubris, warn that an exclusive focus on technology disregards the fact that war is an inherently human and non-linear phenomenon, subject to the clash of wills (Murray, 1997).

Within this context of theoretical confrontation between the promises of the digital age and the immutability of the nature of war, the central question of this essay arises: how can technological modernity change war and national strategies in the near future?

The hypothesis to be investigated in this work is that technology, rather than altering the fundamental nature of war or eliminating friction, acts by reconfiguring political options and national strategies. It is postulated that the friction of war tends to shift from the tactical front line to the cognitive dimension of decision-makers and, above all, to the logistical-industrial capacity of the state and its integration with the civilian sector (Amarante, 2012; King, 2025).

Methodologically, the research adopts a qualitative approach operationalised through an exploratory case study. In the following sections, after the review of the theoretical framework, the modernisation of the Russian Defence Industrial Complex, the logistical burden evidenced in the war in Ukraine and the strategic compensations adopted through hybrid and multi-domain actions will be analysed. In this way, the aim is to test the applicability of the concept of friction in direct counterpoint to the promises of automation and of the Revolution in Military Affairs (RMA), demonstrating the shift of the friction of war from the front line to the industrial and institutional rear of the state, further reaching the cognitive dimension of decision-makers.

Still with regard to the methodological path, in observance of the guidelines of academic integrity and transparency in scientific research, the authors declare the use of an Artificial Intelligence tool, based on a Large Language Model, as an auxiliary resource in the elaboration of this essay. Claude (Anthropic, version Opus 4.8) was used to verify the correctness of the writing, the translation of the abstract into English and Spanish, and the adequacy of the formatting to the standards of the Associação Brasileira de Normas Técnicas (ABNT). It should be emphasised that the formulation of the research problem, the design of the hypothesis, the selection of the literature, the empirical analysis and the final considerations are of the exclusive authorship and responsibility of the researchers, who wrote, reviewed and edited the content in its entirety, preserving the intellectual reflection presented.

2 THE THEORETICAL DEBATE: THE TECHNOLOGICAL UTOPIA AND THE NATURE OF FRICTION

The rise of information technologies drove a profound theoretical debate on the possibility of taming the unpredictable nature of combat through superiority in data processing (Elward, 2010). The theory of Network-Centric Warfare (NCW), introduced by thinkers such as Cebrowski and Garstka, argues that the uninterrupted interconnection of sensors and shooters generates a self-synchronisation capable of surpassing the adversary's decision cycle, translating information superiority into competitive advantage and accelerating the

pace of operations (Cebrowski; Garstka, 1998). For the advocates of this technological revolution, the application of advanced networks of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) would provide an omniscient view of the battlefield, proposing the substantial dissipation of the fog of war and of uncertainty at the strategic level (Owens; Offley, 2000).

However, a significant part of the strategic literature opposes this utopian vision, drawing on the foundations of Clausewitz's theory (Murray, 1997). For the critical strand, war remains an inherently non-linear phenomenon, characterised by the paradoxical trinity and inseparably linked to chance and primordial violence (Clausewitz, 2010; Knox; Murray, 2001). Williamson Murray classifies as “technological arrogance”, hubris, the attempt to replace the political and human understanding of war with quantitative fascination with sensors and computers (Murray, 1997). Along these same lines, it is argued that the premise of absolute informational dominance ignores the realities of human nature and the capacity of opponents to adopt asymmetric measures that establish chaos (Elward, 2010).

Artificial Intelligence (AI) and automation, at the current stage of this debate, have assumed the centre of the discussions on the possible reduction of military friction (King, 2025). Enthusiasts of this evolution suggest that algorithms could free decision-making from the inhibitions, frailties and fear characteristic of human psychology (King, 2025). However, King points out that current AI acts fundamentally as a statistical engine for the treatment of Big Data with a focus on tasks such as planning, engagement and cyber actions, always requiring human control and parameters (King, 2025). It is theorised that the adoption of these technologies does not automate strategy independently, but subordinates the Armed Forces to a complex arrangement in which data engineers and the civilian technological infrastructure integrate the operational headquarters, redefining the 20th-century Western model (King, 2025).

In order to understand the exact impact of these technological dynamics on the combatant, researchers have updated the taxonomy of the friction of war. Tavares, Ramos and Franchi (2018), supported by the studies of Barry Watts and the complementary theory of Malkki and Malkki, propose that modern friction acts directly on the cognitive and emotional dimensions of military personnel. It was found that the gigantic volume and speed of the information gathered by digitisation may, in fact, overload the decision-making process (Elward, 2010). The danger of death, the imperfection in the curation of data and the adverse conditions trigger the same mechanisms of psychological self-preservation that restrict the flexibility of the leadership's reasoning, limiting its efficiency regardless of the technology embedded in operations (Tavares; Ramos; Franchi, 2018).

This confrontation, between the North American technocentric premise of the elimination of the fog and the theory that attests to the reconfiguration of friction in the cognitive and institutional-rear spheres, makes it imperative to analyse how these dynamics effectively manifest themselves in the combat zones of the 21st century. Verifying which theories are validated requires the observation of the empirical phenomenon of war, encompassing the industrial imperatives, the networked logistics and the stress test of disruptive armaments, themes that structure the analysis that follows.

3 THE LOGISTICAL BURDEN AND THE RESTRUCTURING OF THE DEFENCE INDUSTRIAL BASE

As states seek to overcome friction on the tactical battlefield through digitisation and precision weapons, they insert a new and substantial layer of friction into the material dimension: logistical friction. As Amarante (2012) elucidates, the incorporation of modern technological combat functions into integrated systems creates apparatuses of very high cost and complexity. As a result, the logistical weight of operations grows exponentially, demanding from the state extensive prior political and productive preparation (Duarte, 2012). Technological advancement thus requires that strategic advantage come to depend critically on the uninterrupted mobilisation of the Defence Industrial Base (DIB).

The empirical application of this logistical-institutional imperative is revealed paradigmatically in the trajectory of the Russian Federation in the 21st century. The operational deficiencies exposed during the War in Georgia (2008) made clear to Moscow that the adoption of modern tactics clashed with the structural obsolescence of its productive base, triggering the need for a profound Military Reform (Grass, 2022). The main milestone of this turning point was the announcement, in 2010, of the State Armament Program (GPV 2020), which initially allocated around 600 billion dollars to the development of new technologies and war materiel over the course of a decade (Oliveira, 2024).

In order to absorb this volume of investments and attempt to mitigate the logistical friction of modernisation, Russian state planning promoted a radical verticalisation of the management of its Defence Industrial Complex. The government created state-owned mega-corporations, holdings, most notably Rostec, created in 2007, which came to encompass hundreds of high-technology organisations and industries. The objective of this manoeuvre was to concentrate research, development and production resources in order to avoid duplication of efforts and to optimise the delivery of the material means required by the Armed Forces (Grass, 2022).

One of the most notable examples of this institutional adaptation to the costs of modern war was the prioritisation of the Iskander Tactical Ballistic Missile System (SMBT) within the scope of the GPV. The choice to develop and modernise the Iskander, in its M version, equipped with optical matching and anti-missile decoys, reflects a decision strictly based on cost-benefit. The employment of high-precision tactical ballistic missiles was considered a more economical and logistically efficient alternative to replace the costly and vulnerable conventional close air attacks (Oliveira, 2024).

However, the attempt to achieve technological autarky and to isolate the Russian DIB from the friction imposed by the international system proved to be an illusion. With the Western sanctions applied after the annexation of Crimea (2014) and toughened in 2018, Russia attempted to implement an import substitution policy (Oliveira, 2024). The report of the Center for Naval Analyses (CNA) demonstrates that this policy failed to provide Russia with independence, since the production of advanced systems, such as the precision missiles themselves, remained dependent on Western machine tools and microprocessors (Gorenburg *et al.*, 2024). To sustain the war effort from 2022 onwards, the Russian state was forced to govern this industrial friction by resorting to parallel imports and external cooperation, the supply of drones and munitions by allied countries, demonstrating that modern military power is hostage to the global supply chains (Gorenburg *et al.*, 2024).

It is at the intersection between this industrial burden and the conduct of operations that the materialisation of the change in national strategies is observed. Refuting the technocentric thesis of rapid victories, the Russian military strategy in the invasion of Ukraine in 2022 was rigidly circumscribed by its logistical limitations. The deep dependence of the Russian land forces on the railway network for the supply of massive volumes of munitions, combined with the scarcity of truck transport over long distances, limited the range of action and the pace of advance of the troops (Diniz, 2025).

Faced with this material friction, and with the proliferation of sensors and drones that made the battlefield transparent (Ferreira, 2025), the intended war of movement failed. Russia was forced to align its strategy with the logistical imperatives, adopting the doctrine of “Active Defence”, based on systematic bombardments and on a positional war of attrition (Diniz, 2025; Ferreira, 2025). Technology, when disconnected from a resilient logistical and productive capacity, acts as a severe operational limiter. It is precisely in order to attempt to circumvent this material attrition and break the paralysis imposed by positional friction that the major powers begin to seek compensations in other spheres of the conflict, orchestrating other types of multi-domain strategies.

4 MULTI-DOMAIN INTEGRATION AND HYBRID ACTIONS AS STRATEGIC COMPENSATION

The finding that technological parity and sensor saturation generated a transparent battlefield made unfeasible the fluidity of the large concentrations of armoured troops (Ferreira, 2025). Faced with this transparency and with the severe logistical burden required to sustain the war of attrition, contemporary powers found themselves obliged to seek strategic alternatives to circumvent direct and exhausting kinetic engagement. The solution found to compensate for industrial limitations and break the positional paralysis was the orchestration of hybrid strategies and multi-domain actions, with the aim of transferring friction to the adversary's decision-making process and infrastructure.

In Russian military thought, the search for compensations materialised in the adoption of flexible operational concepts, frequently encompassed in the West under the nomenclature of Hybrid Warfare. This definition is conceptually imprecise for the Russian school, which adopts the terminology of “New Generation Warfare”, a formulation of its own for achieving political objectives through the combined use of asymmetric actions and low-intensity conflicts (Giles, 2020). In the Western debate, this change in the Russian posture was erroneously popularised under the label of the “Gerasimov Doctrine”. The expression, coined in 2014 by the researcher Mark Galeotti, became a distorted paradigm and forced the author himself to publicly retract for having created this term that does not exist in the formality of Moscow's manuals (Giles, 2020; Volpe, 2024).

The genesis of this international misunderstanding dates back to an article published in February 2013 in the newspaper *Courier Industriel Militaire* by the Russian Chief of the General Staff, Valery Gerasimov. In his text, the general did not formulate a new aggressive doctrine, but rather analysed and criticised the regime-change tactics used by the Western countries during the Arab Spring, in Libya and Syria (Giles, 2020; Plekhanov, 2021). Gerasimov warned that, in the 21st century, the border between the states of war and peace had become blurred, and that the orchestrated use of political, economic and informational measures frequently surpassed the effectiveness of the force of conventional arms (Giles, 2020; Plekhanov, 2021).

Far from being a revolutionary and sudden invention of Gerasimov, this approach recovers classical theories of the Russian school, adapting them to the digital age. Ideas such as “Rebellion Warfare”, *Myatezh Voina*, theorised in the 1950s and 1960s by the exiled colonel and professor Evgeny Messner, already conceived a conflict waged primarily in the psychological dimension, aiming at the fission of the psyche and the moral incapacitation of the adversary (Klus, 2016). The concept advocates the employment of irregular forces, terrorism and civil agitation orchestrated under a highly ambiguous strategic design, with the

aim of confusing the victim's perception, relegating the regular Armed Forces to a merely auxiliary role (Klus, 2016). In absorbing this heritage, contemporary Russian military strategy advocates that non-military actions, political, economic, informational and cyber, must act in conjunction with conventional military power, with a significantly greater relative weight, illustrated by Lopes (2021) in an approximate proportion of four non-military measures for each strictly military action.

The central axis that consolidates this hybrid strategy and makes viable the manipulation of the enemy's fog of war lies in the intensive employment of the theory of Reflexive Control. Developed historically within Soviet military doctrine by Vladimir Lefebvre, Reflexive Control is defined as the process by which one of the opponents transmits the motives and grounds for the decision-making of its adversary, voluntarily inducing it to adopt an action favourable to the initiator of the control (Lopes, 2021).

By applying Reflexive Control combining deception, maskirovka, demonstrations of force, social media, cyberattacks and the employment of proxy forces, such as militias and private military companies, the attacker achieves operational results projecting power with a significantly lower logistical demand. The objective ceases to be total physical annihilation, typical of industrial war, and becomes the induction of paralysis, exhaustion and the perception of despair in the opposing political and military leaderships (Lopes, 2021). Technological modernity offers new cyber and mass-communication tools so that the state may reconfigure the attrition, inserting conflicting and false data that affect the cognitive and emotional dimensions of the adversary's decision-makers.

The materialisation of this theory on the contemporary battlefield in Ukraine has revealed the inseparable convergence between land operations and the Cyber, Electronic and Space domains. According to Pinto (2025), Electronic Warfare (EW) has become an intrinsic part of the manoeuvre, using tactics of frequency blocking, jamming, and the sending of false signals, spoofing, to neutralise the opponent's drone constellations and guided artillery. Simultaneously, the offensives in cyberspace target critical civilian and military infrastructures, combining physical sabotage with psychological operations.

However, it is in the Space domain that the reconfiguration of national strategies, driven by what King (2025) called the Military-Technological Complex, shows itself most acutely. The war in Ukraine revealed the dependence of the contemporary Armed Forces on constellations of commercial satellites, such as Starlink, Maxar and Planet, to guarantee situational awareness, remote sensing and encrypted communications under heavy interference attack (Pinto, 2025; Teixeira Júnior; Santos; Gomes, 2025).

The combined employment of drones, missiles, electronic warfare and cyber intelligence acts in a complementary and multi-domain manner, requiring the state to drastically expand its coordination with the private technology sector. State actors pursue, within this tactical and strategic dynamic, a continuous effort of manipulation of the adversary's friction, preserving their own freedom of action in the face of the volatility of the globalised informational networks of the 21st century.

5 FINAL CONSIDERATIONS

The present theoretical essay sought to investigate how technological modernity may change war and national strategies in the near future, contrasting the technocentric premises of the Revolution in Military Affairs (RMA) with the enduring foundations of Clausewitz's strategic theory. Throughout the research, it was verified that the fascination with Network-Centric Warfare (NCW), postulated by authors such as Cebrowski and Garstka (1998) and Owens and Offley (2000), and with Artificial Intelligence generated the false expectation that data superiority could dissipate the fog of war and eliminate human friction from the battlefield.

The theoretical analysis, grounded in the studies of Murray (1997), Elward (2010), Tavares, Ramos and Franchi (2018) and of Anthony King (2025), demonstrated that technology does not suppress friction, but transforms and amplifies it. The informational excess inherent to digitisation imposes a heavy overload on the cognitive and emotional dimensions of decision-makers. Moreover, the complexity of modern weapons systems subordinates the Armed Forces to an emerging Military-Technological Complex, inserting civilian corporations and specialists directly into the Command and Control cycle, which creates new institutional variables and vulnerabilities.

Empirically, the examination of the modernisation of Russia's Defence Industry (Grass, 2022; Oliveira, 2024) and the evidence from the Russo-Ukrainian conflict corroborated the initial hypothesis of this study. The massive employment of sensors, drones and precision artillery generated a highly transparent battlefield, frustrating the attempts at fluid and rapid wars of movement (Teixeira Júnior; Santos; Gomes, 2025). Instead of making the conflict bloodless, technology imposed a return to positional war of high attrition (Ferreira, 2025). Strategic advantage fell upon the logistical burden. The success of operations became hostage to the capacity for uninterrupted mobilisation of the Defence Industrial Base (DIB) and to the limited railway and road supply chains (Diniz, 2025).

To compensate for the prohibitive cost of this material attrition, states began to orchestrate hybrid and multi-domain strategies. The employment of cyberspace, of electronic

warfare and of dual-use space infrastructure, civilian and military, acts in synergy with other strategies such as Russian Reflexive Control (Pinto, 2025; Lopes, 2021). This approach aims to transfer friction directly to the mind of the opposing leadership and to the enemy's critical infrastructure, prioritising moral and political exhaustion to the detriment of strictly physical annihilation (Klus, 2016; Volpe, 2024).

It is concluded, therefore, that technological modernity does not alter the fundamental and paradoxical nature of war, which continues to be a clash of human wills permeated by chance and violence. It reconfigures national strategies, shifting the centre of gravity of tactical manoeuvre from the front line to the state's capacity to govern friction in its rear. In the 21st century, victory will depend on the aptitude of the political and military leadership to integrate civil-military innovation, sustain the long-term logistical-industrial effort and dominate the informational environment in the face of the uncertainty of combat.

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EVALUATION OF THE UTERUS AND HEART OF FEMALE MUS MUSCULUS EXPOSED TO CANNABIS SATIVA EXTRACT

AVALIAÇÃO DO ÚTERO E CORAÇÃO DE FÊMEAS DE CAMUNDONGOS MUS MUSCULUS EXPOSTAS AO EXTRATO DE CANNABIS SATIVA

EVALUACIÓN DEL ÚTERO Y CORAZÓN DE HEMBRAS DE RATONES MUS MUSCULUS EXPUESTOS AL EXTRACTO DE CANNABIS SATIVA

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ABSTRACT

The increasing resistance of ticks to synthetic acaricides, together with concerns regarding their toxicological and environmental effects, has encouraged the search for plant-derived compounds with potential use in ectoparasite control. In this context, Cannabis sativa has emerged as a species of biotechnological interest due to its wide diversity of bioactive metabolites, including cannabinoids and terpenes. However, in addition to efficacy, the possible effects of plant extracts on non-target organisms must also be evaluated. Thus, the present study investigated the effects of spray exposure to C. sativa extract (2.5 mg/mL) on the histology and histochemistry of the uterus and heart of female Mus musculus mice. Fifteen Swiss females were distributed into three experimental groups: distilled water control, 30% ethanol (v/v) control, and treatment with C. sativa extract diluted in 30% ethanol. Exposures were carried out on three consecutive days and, after 14 days, the animals were euthanized for organ collection. Samples were processed for light microscopy after staining with hematoxylin-eosin and bromophenol blue. In the uterus, the treated group showed mild cytoplasmic vacuolization in glandular cells, more evident stromal vascular congestion, and vacuolated spaces between connective tissue cells, without evidence of hemorrhage,

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necrosis, or extensive structural disorganization. In the heart, a focal increase in interfibrillar spaces and slight irregularity in myocardial fiber alignment were observed, with preservation of the overall tissue architecture. Bromophenol blue revealed a slight reduction in protein staining intensity in the treated group. Overall, exposure to *C. sativa* extract (2.5 mg/mL) was associated with mild morphological and histochemical alterations, without evidence of severe structural damage in the analyzed organs.

Keywords: *Cannabis sativa*. Heart. Morphology. Toxicity. Uterus.

RESUMO

A crescente resistência dos carrapatos aos acaricidas sintéticos, associada às preocupações relacionadas aos seus efeitos toxicológicos e ambientais, tem incentivado a busca por compostos de origem vegetal com potencial aplicação no controle de ectoparasitas. Nesse contexto, *Cannabis sativa* tem se destacado como uma espécie de interesse biotecnológico devido à ampla diversidade de metabólitos bioativos, incluindo canabinoides e terpenos. No entanto, além da eficácia, os possíveis efeitos dos extratos vegetais sobre organismos não alvo também devem ser avaliados. Assim, o presente estudo investigou os efeitos da exposição, por pulverização, ao extrato de *C. sativa* (2,5 mg/mL) sobre a histologia e a histoquímica do útero e do coração de camundongos fêmeas *Mus musculus*. Quinze fêmeas Swiss foram distribuídas em três grupos experimentais: controle com água destilada, controle com etanol 30% (v/v) e tratamento com extrato de *C. sativa* diluído em etanol 30%. As exposições foram realizadas durante três dias consecutivos e, após 14 dias, os animais foram eutanasiados para a coleta dos órgãos. As amostras foram processadas para microscopia de luz e submetidas às colorações por hematoxilina-eosina e azul de bromofenol. No útero, o grupo tratado apresentou discreta vacuolização citoplasmática nas células glandulares, congestão vascular estromal mais evidente e espaços vacuolizados entre as células do tecido conjuntivo, sem evidências de hemorragia, necrose ou extensa desorganização estrutural. No coração, foram observados aumento focal dos espaços interfibrilares e discreta irregularidade no alinhamento das fibras miocárdicas, com preservação da arquitetura geral do tecido. A coloração por azul de bromofenol revelou discreta redução na intensidade da marcação proteica no grupo tratado. De modo geral, a exposição ao extrato de *C. sativa* (2,5 mg/mL) esteve associada a alterações morfológicas e histoquímicas discretas, sem evidências de danos estruturais graves nos órgãos analisados.

Palavras-chave: *Cannabis sativa*. Coração. Morfologia. Toxicidade. Útero.

RESUMEN

La creciente resistencia de las garrapatas a los acaricidas sintéticos, junto con las preocupaciones sobre sus efectos toxicológicos y ambientales, ha fomentado la búsqueda de compuestos de origen vegetal con potencial uso en el control de ectoparásitos. En este contexto, *Cannabis sativa* ha surgido como una especie de interés biotecnológico debido a su amplia diversidad de metabolitos bioactivos, incluidos cannabinoides y terpenos. Sin embargo, además de la eficacia, también deben evaluarse los posibles efectos de los extractos vegetales en organismos no objetivo. Así, el presente estudio investigó los efectos de la exposición por pulverización al extracto de *C. sativa* (2,5 mg/mL) sobre la histología e histoquímica del útero y corazón de ratones hembra *Mus musculus*. Quince hembras Swiss se distribuyeron en tres grupos experimentales: control con agua destilada, control con etanol al 30% (v/v) y tratamiento con extracto de *C. sativa* diluido en etanol al 30%. Las exposiciones se realizaron durante tres días consecutivos y, después de 14 días, los animales fueron eutanasiados para la recolección de órganos. Las muestras se procesaron para microscopía óptica tras tinción con hematoxilina-eosina y azul de bromofenol. En el útero, el grupo tratado mostró leve vacuolización citoplasmática en células glandulares, congestión vascular estromal más evidente y espacios vacuolizados entre células del tejido conjuntivo, sin

evidencia de hemorragia, necrosis o extensa desorganización estructural. En el corazón, se observó un aumento focal de los espacios interfibrilares e irregularidad leve en la alineación de las fibras miocárdicas, con preservación de la arquitectura general del tejido. La tinción con azul de bromofenol reveló una ligera reducción en la intensidad de tinción de proteínas en el grupo tratado. En general, la exposición al extracto de *C. sativa* (2,5 mg/mL) se asoció con alteraciones morfológicas e histoquímicas leves, sin evidencia de daño estructural grave en los órganos analizados.

Palabras clave: *Cannabis sativa*. Corazón. Morfología. Toxicidad. Útero.

1 INTRODUCTION

Ticks are hematophagous arthropods of medical and veterinary importance, as they cause lesions in their hosts and act as vectors of pathogenic agents (Camargo-Mathias *et al.*, 2024; Nasreen *et al.*, 2020;). In recent decades, their geographic expansion has been favored by anthropogenic factors such as climate change, habitat fragmentation, and changes in host availability (Saleh *et al.*, 2021). The control of these ectoparasites has relied largely on the use of synthetic acaricides; however, the continuous use of these compounds has contributed to the selection of resistant populations, in addition to raising concerns regarding their potential toxicological and environmental impact (Obaid *et al.*, 2022; Shanmuganath *et al.*, 2021).

In this context, natural compounds of plant origin have received increasing attention as potentially safer and more sustainable alternatives for tick control (Wanzala, 2017). Among them, *Cannabis sativa* L. stands out because of its broad biological potential, mainly associated with the presence of cannabinoids and terpenes (Guerra *et al.*, 2023; Valizadehderakhshan *et al.*, 2021). Studies using extracts of this species in *Rhipicephalus linnaei* ticks have demonstrated effects on biological parameters and different tissues, including damage to tegumental and glandular structures, suggesting its potential as a natural acaricide (Camargo-Mathias *et al.*, 2024).

Despite these promising results, the proposal of new compounds for use in ectoparasite control requires, in addition to the demonstration of efficacy, the investigation of possible effects on non-target organisms. In this regard, the histological evaluation of host organs constitutes an important step in assessing the biological safety of exposure to the compound. Preclinical studies in rodents using *C. sativa* preparations reinforce the importance of investigating possible pharmacological and morphological effects in different organs, including tissues of the female reproductive system, thereby contributing to the biological safety assessment of these compounds (Araújo *et al.*, 2024; Lima *et al.*, 2021).

Among the organs of interest, the heart exhibits a highly specialized structural organization, composed of the endocardium, myocardium, and epicardium, whose integrity is essential for normal cardiac function (Leung; Zhou; Lui, 2016). Likewise, the uterus presents a well-defined histological organization, consisting of the endometrium, myometrium, and perimetrium, and is a relevant organ in the investigation of possible tissue alterations in females exposed to biologically active compounds (Al-Shaeli *et al.*, 2024; Roesler *et al.*, 2025). In addition to their morphofunctional relevance, the heart and uterus are tissues responsive to endocannabinoid signaling, which further emphasizes the importance of their

evaluation in studies of exposure to compounds derived from *C. sativa* (Paria; Dey, 2000; Pacher; Steffens, 2009).

Thus, considering the acaricidal potential of the *C. sativa* inflorescence extract and the need to investigate its safety in non-target organisms, the present study aimed to evaluate the effects of exposure to the extract, at a concentration of 2.5 mg/mL, on the histology and histochemistry of the heart and uterus of female *Mus musculus*.

2 MATERIALS AND METHODS

2.1 CANNABIS SATIVA EXTRACT

The crude extract of the *C. sativa* inflorescence was provided by the Associação Canábica Maria Flor, located in the city of Marília, São Paulo, Brazil, and produced under the technical supervision of Dr. Caroline Marroni Cremonez, Scientific Director of the Association. The phytochemical analysis was carried out by DALL Soluções Analíticas e Empresariais, located in Curitiba, Paraná, Brazil, and supervised by Dr. Gustavo Bertol, Technical Manager of the company, in partnership with the Associação Canábica Maria Flor.

The crude extract was diluted in a 30% ethanol solution (v/v), prepared in distilled water, in order to obtain the final concentration of 2.5 mg/mL, established based on previous studies conducted with ticks of the species *Rhipicephalus microplus* and *Rhipicephalus linnaei* (Camargo-Mathias, 2024; Nasreen *et al.*, 2020).

2.2 MUS MUSCULUS MICE

Fifteen healthy Swiss female mice of the species *Mus musculus*, weighing approximately 40 g and aged between 8 and 10 weeks, were obtained from the Center for Research and Animal Production (CPPA) of UNESP, Botucatu, São Paulo, Brazil. The animals were housed in the animal facility of the Institute of Biosciences (IB), in identified rectangular polypropylene cages (30 × 20 × 13 cm), with five animals per cage, under standard conditions of temperature (22°C ± 2°C), humidity (50%), appropriate ventilation, exhaust system, 12 h photoperiod, and were provided with food and water *ad libitum*.

2.3 EXPOSURE OF FEMALE MUS MUSCULUS MICE TO C. SATIVA EXTRACT BY SPRAYING

The 15 female *M. musculus* mice (5/group) were divided into the following groups:

- **Control Group 1 (CG1):** exposed to distilled water;
- **Control Group 2 (CG2):** exposed to 30% ethanol, the solvent used for the extract;
- **Treatment Group (T1):** exposed to the extract at a concentration of 2.5 mg/mL.

The exposures were carried out on three consecutive days, with 24 h intervals between them, using sterilized sprays, according to the protocol previously described by Cunha *et al.* (2017), simulating the application of commercial acaricides to host animals. The *Cannabis* extract was sprayed onto the dorsal region of the animals while protecting the head and preventing the compound from entering through other routes (nose, eyes, ears and mouth).

After exposure, the animals were observed daily for 14 days. On day 14, all animals were euthanized by overdose of anesthetic agents using ketamine hydrochloride (80 mg/kg BW/IP) and xylazine hydrochloride (20 mg/kg BW/IP), and the uterus and heart were collected. Organ removal procedures were performed by veterinarian Gabriel Correa de Camargo, CRMV No. 52730. Immediately after collection, these structures were fragmented and fixed in 4% paraformaldehyde.

All procedures were submitted to and approved by the Animal Ethics Committee (CEUA, Institute of Biosciences, UNESP – Rio Claro campus), under protocol No. 000549.

2.4 HISTOLOGICAL AND HISTOCHEMICAL ANALYSIS OF THE UTERUS AND HEART

The organs remained fixed in 4% paraformaldehyde for one week. After fixation, they were washed twice in 0.1 M sodium phosphate buffer. They were then dehydrated through an ascending ethanol series (70%, 80%, 90%, and 95%), with 20 min intervals at each concentration, and subsequently infiltrated with Leica Histoiresin® (Leica Biosystems, Nussloch, Germany) for seven days. After this period, the material was embedded in plastic molds containing resin and polymerizer and kept in an oven at 37°C for an additional seven days for polymerization.

The blocks were then sectioned using a LEICA RM2255® microtome (Leica Biosystems, Nussloch, Germany), obtaining sections 3 µm thick, which were collected on glass slides and stored in an oven for drying.

Part of the slides was subjected to hematoxylin-eosin (HE) staining. For this, the sections were hydrated in distilled water for 1 min, stained with hematoxylin (Sigma-Aldrich, St. Louis, MO, USA) for 10 min, and washed for 4 min in still water, followed by washing in running water. Next, they were stained with aqueous eosin (Sigma-Aldrich, St. Louis, MO, USA) for 5 min and again washed in running water. After drying at room temperature, the slides were mounted in permanent medium with Entellan® (Merck Millipore, Darmstadt, Germany). The permanent slides were analyzed and photodocumented under a Leica® DM750 bright-field microscope (Leica Microsystems, Wetzlar, Germany).

Another part of the slides was subjected to bromophenol blue staining (Sigma-Aldrich, St. Louis, MO, USA) for 1 h at room temperature. After staining, the slides were immersed in

0.5% acetic acid for 5 min and washed in running water for 15 min. They were then rapidly passed through tertiary butyl alcohol solution, air-dried, and mounted in permanent medium with Entellan® (Merck Millipore, Darmstadt, Germany). The permanent slides were analyzed and photodocumented under a Leica® DM750 bright-field microscope (Leica Microsystems, Wetzlar, Germany) at the Histology Laboratory of the Department of General and Applied Biology, IB/UNESP, Rio Claro, São Paulo, Brazil.

3 RESULTS

3.1 UTERUS

3.1.1 Hematoxylin and Eosin (HE) staining

The results obtained in the present study showed that, in the control group exposed to distilled water, the uterus exhibited preserved architecture/musculature (**Fig. 1A**). The endometrial glands displayed a well-defined tubular morphology and homogeneous distribution within the stroma (**Fig. 1A**), which showed uniform cellularity, with blood vessels of normal caliber and no evidence of blood congestion (**Fig. 1A**). In the myometrium, smooth muscle bundles were organized, with fibers arranged in parallel and elongated nuclei also preserved (**Fig. 1A**).

In the control group exposed to ethanol (30%), the uterine tissue was also found to be preserved (**Fig. 1B**). Mild blood congestion was observed in the stroma, characterized by the marked presence of erythrocytes, with no alteration in the associated connective tissue (**Fig. 1B**). Some glandular epithelial cells showed cytoplasmic vacuolization, without impairment of glandular organization (**Fig. 1B**). The myometrium remained organized (**Fig. 1B**).

In the group exposed to *Cannabis sativa* extract (2.5 mg/mL), mild morphological alterations were observed when compared with the control groups (**Fig. 1C**). The endometrial glands showed cells with cytoplasmic vacuolization (**Fig. 1C**). In the stroma, more evident blood congestion was observed compared with the control groups, but without signs of hemorrhage, necrosis, or cellular disorganization (**Fig. 1C**). The stroma also exhibited vacuole-like spaces between connective tissue cells (**Fig. 1C**). The myometrium remained organized, with no fragmentation or structural disarrangement (**Fig. 1C**).

3.1.2 Histochemistry (Bromophenol Blue)

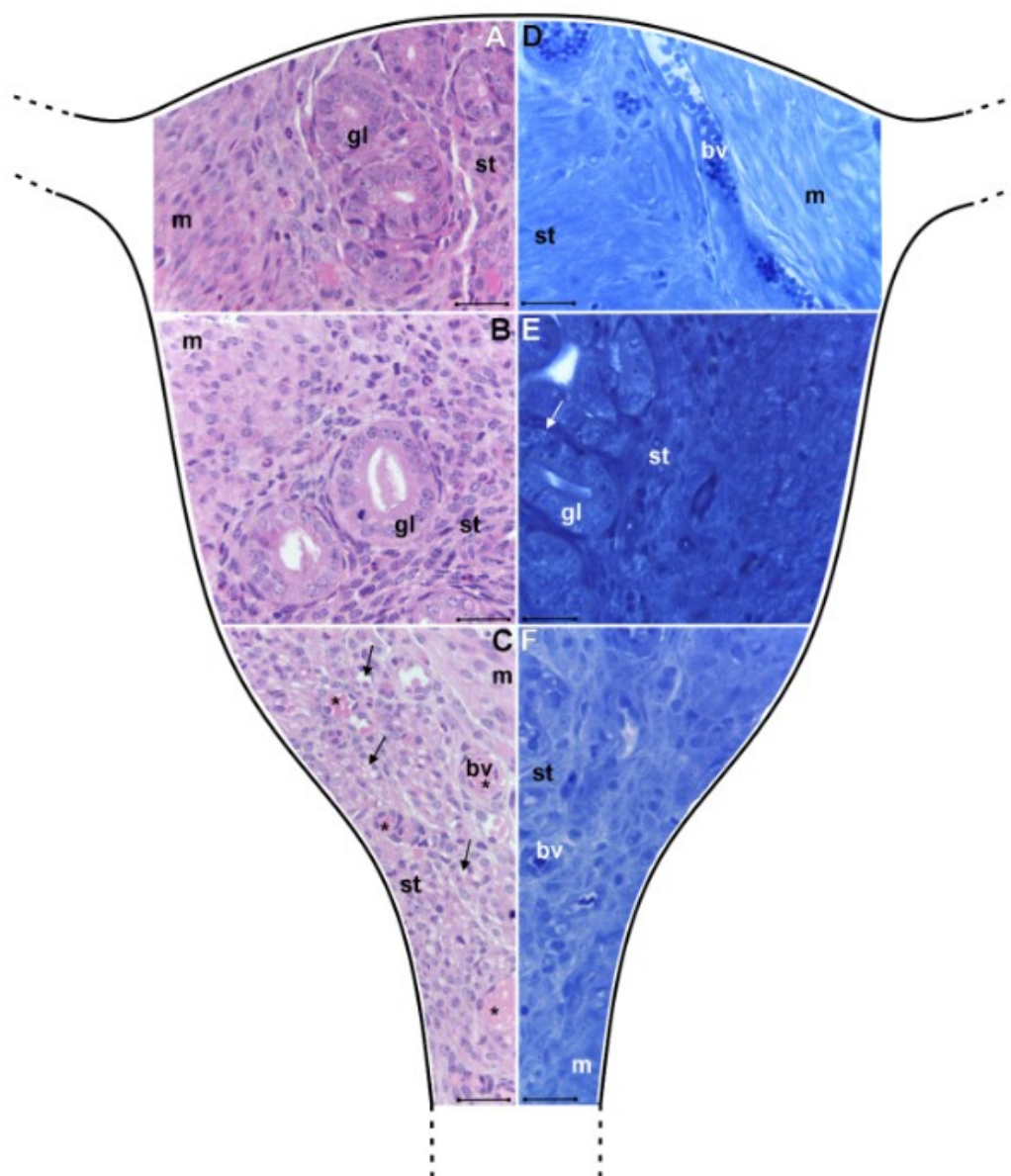
In the water control group, bromophenol blue staining demonstrated homogeneous and intense protein labeling in the glandular cells and stroma, indicating a uniform pattern of total proteins (**Fig. 1D**).

In the ethanol control group, the staining intensity remained relatively homogeneous, with slight variation in intensity in glandular areas (**Fig. 1E**).

In the group treated with *C. sativa* (2.5 mg/mL), a slight reduction in the intensity of protein labeling was observed in the glandular cells when compared with the controls, while the structural preservation of the tissue was maintained (**Fig. 1F**).

Figure 1

Histological sections of the uterus of female Mus musculus treated and untreated with Cannabis sativa extract, stained with hematoxylin-eosin (A-C) and bromophenol blue (D-F). A-D: water control; B-E: 30% ethanol control; C-F: treatment group treated with C. sativa extract at 2.5 mg/mL



Legend: bv: blood vessel; gl: endometrial glands; m: myometrium; st: stroma; black arrow: vacuolization; asterisk (*): blood congestion; white arrow: protein accumulation. Bars (A-F): 50 μ m.
Source: The authors.

3.2 HEART

3.2.1 Hematoxylin and Eosin (HE) staining

In the water control group, the myocardium showed fibers organized in parallel bundles, with cardiomyocytes displaying well-defined contours, homogeneous eosinophilic cytoplasm, and preserved central nuclei (**Fig. 2A**). No relevant structural alterations were observed.

In the ethanol control group, the overall organization of the myocardial bundles was preserved (**Fig. 2B**). The cardiomyocytes exhibited intact morphology, with no evidence of cell death (**Fig. 2B**).

In the group exposed to *C. sativa* extract (2.5 mg/mL), an increase in interfibrillar spaces was observed in certain areas, associated with slight irregularity in the alignment of myocardial fibers (**Fig. 2C**). The cardiomyocytes maintained preserved central nuclei and eosinophilic cytoplasm, with no evidence of cell death, fibrosis, or extensive structural disorganization (**Fig. 2C**).

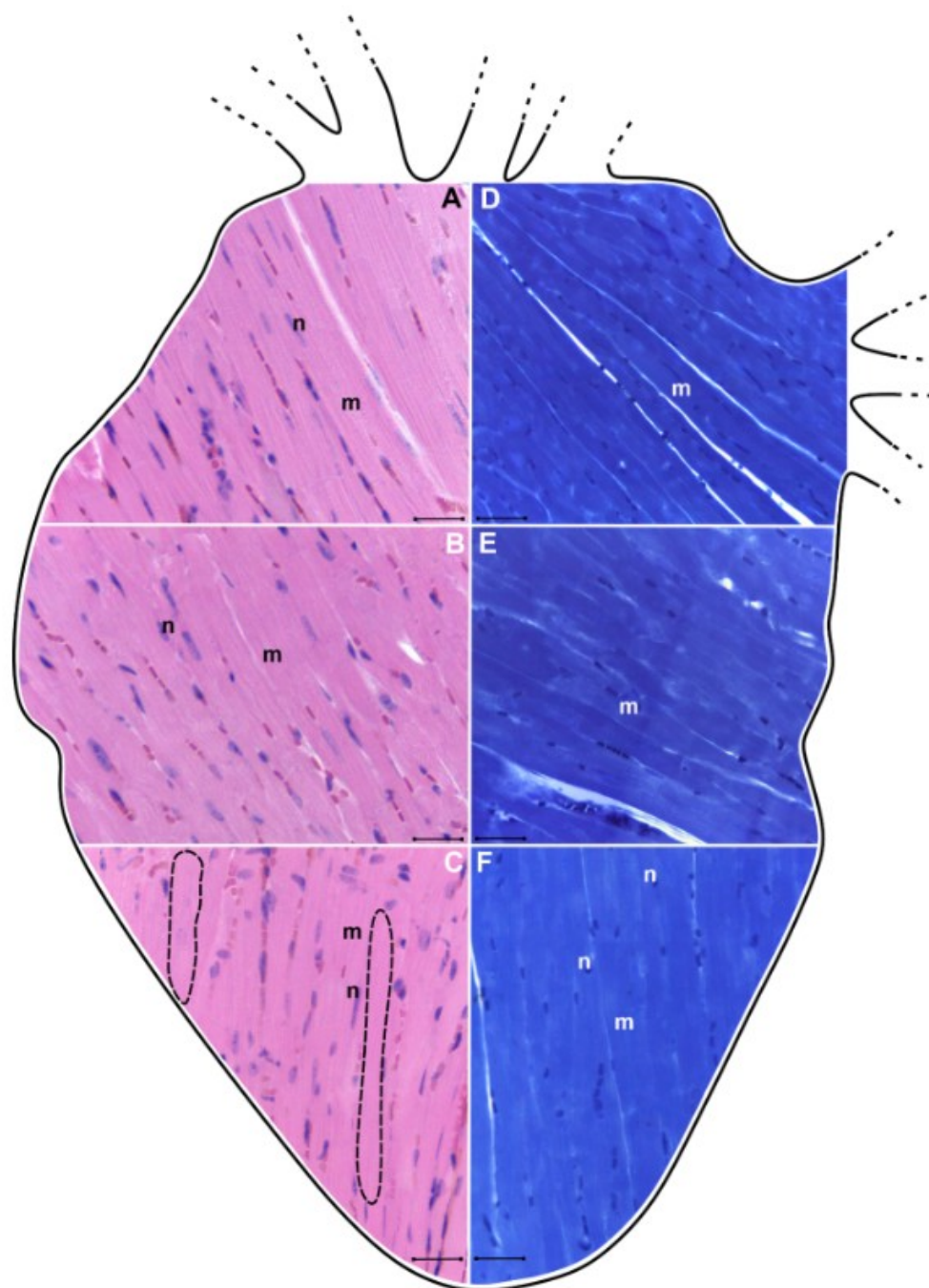
3.2.2 Histochemistry (Bromophenol Blue)

In the control groups, bromophenol blue staining intensity showed homogeneity in the myocardial fibers and cardiomyocytes (**Fig. 2D-E**).

In the group treated with *C. sativa*, a reduction in staining intensity was observed in small areas, while the structural organization of the tissue was maintained (**Fig. 2F**).

Figure 2

Histological sections of the heart of female *Mus musculus* treated and untreated with *Cannabis sativa* extract, stained with hematoxylin-eosin (A-C) and bromophenol blue (D-F). A-D: water control; B-E: 30% ethanol control; C-F: treatment group treated with *C. sativa* extract at 2.5 mg/mL



Legend: m: muscle bundles; n: cell nucleus; dashed line: increase in interfibrillar spaces. Bars (A-F): 50 μ m. Source: The authors.

4 DISCUSSION

The histological analysis of the uterine and cardiac tissues showed that spray exposure to *Cannabis sativa* extract (2.5 mg/mL) promoted mild structural alterations,

predominantly characterized by changes in cellular organization and protein staining intensity, with no evidence of irreversible tissue injury.

In the uterus, the treated group showed mild cytoplasmic vacuolization in glandular epithelial cells and between connective tissue cells of the stroma. The literature shows that endometrial tissue is highly sensitive to hormonal variations and bioactive stimuli and may present mild structural alterations even in the absence of destructive lesions (Hassan, 2025). The alterations observed in the present study suggest changes in the cellular morphofunctional pattern, although without total loss of tissue integrity.

The more evident vascular congestion in the stroma indicates an increased presence of erythrocytes in endometrial vessels, without extravasation or significant structural alteration. Mild vascular changes, such as increased intravascular filling, have already been described in experimental models subjected to hormonal stimuli and plant extracts with bioactive potential, without progression to necrosis or extensive stromal reorganization (Elgayed *et al.*, 2021; Hassan, 2025).

It is important to highlight that no areas of necrosis or cellular alterations suggestive of cell death were identified, indicating that the observed changes were predominantly structural and of low intensity. Experimental studies with *Cannabis sativa* extracts in murine models have also shown a similar profile, with absence of systemic toxicity and preservation of tissue architecture, even after prolonged exposure (Lima *et al.*, 2021). In a complementary way, morphometric analyses of the uterus of females treated with plant extracts did not show relevant structural alterations or organ enlargement (Araújo *et al.*, 2023).

In contrast, experimental models associated with more intense injuries, such as myocardial ischemia and reperfusion, frequently show marked alterations, including hemorrhage, edema, inflammatory infiltration, and significant structural damage (Aksoy *et al.*, 2026). The absence of these findings in the present study reinforces that the observed modifications do not characterize established tissue injury.

Histochemical analysis with bromophenol blue revealed a reduction in protein staining intensity in glandular cells of the treated group. Since this technique demonstrates total cytoplasmic and nuclear proteins, the lower staining intensity may reflect alteration or intracellular redistribution of structural proteins. From a morphological point of view, the association between mild epithelial irregularity and reduced staining intensity suggests a functional modification of glandular cells, although without signs of severe cytotoxicity. Mild cytoplasmic alterations, including variation in staining intensity and mild vacuolization, without evidence of necrosis or structural collapse, have also been described in the uterus of female

mice exposed to *Cleome gynandra* extract, a plant widely reported as capable of inducing uterine contraction (Monima *et al.*, 2019).

In cardiac tissue, the histological findings were also characterized by mild structural alterations. The increase in interfibrillar spaces observed in the treated group indicates mild separation between cardiomyocytes, without rupture of cell boundaries or nuclear fragmentation. Under normal conditions, cardiomyocytes show a parallel organization, with homogeneous eosinophilic cytoplasm and preserved central nuclei (Baudouy *et al.*, 2017).

The irregularity in myocardial fiber alignment observed in this study suggests alterations in myofibrillar organization, although the general arrangement of the bundles remained preserved. In the same way, Simeon and Tosin (2024), in their study on the subchronic toxicity of *Ocimum canum* plant extracts in mice, showed that even in the presence of small variations in myocardial arrangement, the overall cardiac structure remained preserved.

Bromophenol blue staining in the heart revealed reduced protein staining intensity in some areas of the tissue in the treated group. Since myocardial contraction depends on highly organized structural proteins, such as actin and myosin (Pacher & Steffens, 2009), variation in bromophenol blue staining intensity may suggest alteration in the distribution or intracellular protein content, although the technique does not allow differentiation or quantification of proteins, and therefore the interpretation remains limited to the histochemical staining pattern.

In general, both uterine tissue and myocardium maintained their structural organization, and no areas of hemorrhage, necrosis, marked cellular degeneration, or intense tissue disorganization were observed. Alterations such as these are frequently described in studies in which the uterus and heart are exposed to potentially toxic agents, such as plant extracts at high concentrations, environmental toxins, or conditions associated with significant oxidative stress and metabolic imbalance (Akşit *et al.*, 2023). In these situations, the literature reports loss of normal tissue structure, connective tissue reorganization, and presence of inflammatory infiltrate, findings that were not identified in the samples analyzed in this study.

The preservation of uterine and cardiac architecture suggests that, under the experimental conditions used, *Cannabis sativa* extract at the concentration of 2.5 mg/mL did not induce irreversible structural injury. Considering that cannabinoid receptors CB1 and CB2 are present in both reproductive and cardiovascular tissues (Paria & Dey, 2000; Pacher & Steffens, 2009), it is plausible that interaction with these systems may have contributed to the maintenance of tissue integrity, although a deeper understanding of the molecular and functional mechanisms involved is still needed in future studies.

Taken together, the results presented here indicate that exposure to *Cannabis sativa* extract, at the evaluated concentration of 2.5 mg/mL, was associated only with mild structural modifications, with no evidence of significant morphological toxicity in the organs studied.

RESEARCH DATA

All the data produced in this study are available with DOI: 10.6084/m9.figshare.32034543.

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THE TRANSFORMATION OF PUBLIC PROCUREMENT FOR INNOVATION IN BRAZIL: COMPETITIVE DIALOGUE, CPSI, AND TECHNOLOGY TRANSFER

A TRANSFORMAÇÃO DAS COMPRAS PÚBLICAS DE INOVAÇÃO NO BRASIL: DIÁLOGO COMPETITIVO, CPSI E TRANSFERÊNCIA TECNOLÓGICA

LA TRANSFORMACIÓN DE LAS CONTRATACIONES PÚBLICAS DE INNOVACIÓN EN BRASIL: DIÁLOGO COMPETITIVO, CPSI Y TRANSFERENCIA TECNOLÓGICA



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ABSTRACT

This article analyses how Law No. 14,133/2021 and Complementary Law No. 182/2021 transformed the landscape of public procurement by introducing mechanisms geared towards innovation and technology transfer. It examines the impact of the competitive dialogue and of the Public Contract for Innovative Solutions (CPSI) in overcoming the historical limitations of the traditional bidding model, highlighting their potential to promote institutional learning and reduce information asymmetries. The research shows, however, that technology transfer is not automatic, being constrained by barriers such as insufficient technical competences, administrative insecurity and the risks of lock-in in digital solutions. It is concluded that, although the regulatory framework represents significant progress, its effectiveness depends on the state's capacity to internalise knowledge and mitigate technological dependencies.

Keywords: Law No. 14,133/2021. Administrative Efficiency. Informational Asymmetry.

RESUMO

Este artigo analisa de que maneira a Lei nº 14.133/2021 e a Lei Complementar nº 182/2021 transformaram o cenário das contratações públicas ao introduzirem mecanismos voltados à inovação e à transferência tecnológica. Examina-se o impacto do diálogo competitivo e do Contrato Público para Solução Inovadora (CPSI) na superação das limitações históricas do modelo licitatório tradicional, destacando-se seu potencial para promover aprendizagem

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institucional e reduzir assimetrias de informação. A pesquisa evidencia, contudo, que a transferência tecnológica não é automática, sendo limitada por barreiras como insuficiência de competências técnicas, insegurança administrativa e riscos de lock-in em soluções digitais. Conclui-se que, embora o marco normativo represente avanço significativo, sua efetividade depende da capacidade estatal de internalizar conhecimento e mitigar dependências tecnológicas.

Palavras-chave: Lei N° 14.133/2021. Eficiência Administrativa. Assimetria Informacional.

RESUMEN

Este artículo analiza de qué manera la Ley n.º 14.133/2021 y la Ley Complementaria n.º 182/2021 transformaron el escenario de las contrataciones públicas al introducir mecanismos orientados a la innovación y a la transferencia tecnológica. Se examina el impacto del diálogo competitivo y del Contrato Público para Solución Innovadora (CPSI) en la superación de las limitaciones históricas del modelo licitatorio tradicional, destacándose su potencial para promover el aprendizaje institucional y reducir las asimetrías de información. La investigación evidencia, sin embargo, que la transferencia tecnológica no es automática, estando limitada por barreras como la insuficiencia de competencias técnicas, la inseguridad administrativa y los riesgos de lock-in en soluciones digitales. Se concluye que, aunque el marco normativo represente un avance significativo, su efectividad depende de la capacidad estatal de internalizar conocimiento y mitigar dependencias tecnológicas.

Palabras clave: Ley N.º 14.133/2021. Eficiencia Administrativa. Asimetría Informacional.

1 INTRODUCTION

Bidding is a formal and competitive process used by the Public Administration to contract services, acquire goods or carry out works. Bidding may be defined as an administrative procedure in which the public entity, under conditions predetermined in the convening instrument of its respective modality, opens to all interested parties the possibility of formulating proposals, from which the most convenient one will be selected for the conclusion of a contract (Di Pietro, 2022).

The historical evolution of the bidding process in Brazil dates back to 1862, with the first regulations that sought to organise public awards. Since then, the model has undergone successive transformations and improvements, especially throughout the twentieth century, until it culminated in Law No. 8,666/1993, which consolidated a robust, unified bidding system that was broadly applicable to the Public Administration (Pompeu, 2022).

Law No. 8,666/1993 represented a milestone in the consolidation of the legal regime of public procurement, by unifying rules and standardising procedures for all federative entities. Its rigid and detailed character sought to confer legal certainty and to curb irregular practices, structuring modalities, phases, judgment criteria and hypotheses of waiver and non-requirement. Although it played a central role for decades, its emphasis on formality ended up limiting the flexibility necessary for more complex and innovative procurement, which contributed to subsequent legislative movements aimed at modernising the system.

In the first place, it must be said that Law No. 8,666 of 1993 failed in its two main objectives. Conceived to combat corruption and to make public procurement more effective (this second guideline translated, notably, into the express objective of seeking the most advantageous proposal for the Public Administration), the Law unfortunately managed to achieve neither one intent nor the other. Under its aegis, reports of corruption cases continued to abound, especially (but not only) in the contracting of works and services. (Rocha, Vanin, Figueiredo, 2021, p. 21).

Seeking to overcome this scenario of inefficiency and rigidity, the Brazilian legal system inaugurated a new stage in 2021. With the publication of Law 14,133/2021, several institutes that were routinely used were repealed, new procedures were implemented, and the rules on the public agents involved in bidding were modified, among other changes.

Law No. 14,133/2021 (the New Bidding Law) incorporates innovation as one of its express objectives (art. 11, sole paragraph). Aragão (2021) points out that the law inaugurates a new phase in which the interaction between public and private is no longer viewed with suspicion, but becomes collaborative, exemplified by the Competitive Dialogue.

In this scenario of strengthening the culture of innovation in public procurement, it becomes evident that the transformation promoted by Law 14,133/2021 does not occur in isolation.

With the aim of remedying market failures and filling gaps present in public policies, especially regarding the creation of adequate regulatory frameworks, the planning and implementation of promotion actions aligned with local realities, in addition to regulating concepts that until then had no legal provision at the federal level, the Legal Framework for *Startups* and Innovative Entrepreneurship (LC 182/2021) was enacted in June 2021. This legislation establishes incentives not only for *startups* and investors, but also for the State itself and for society, which come to benefit from the innovative solutions that may emerge from it (Alves, 2023).

The Public Contract for Innovative Solutions (CPSI) establishes a differentiated legal regime that authorises the State to carry out performance tests for disruptive technologies in real-use scenarios. According to the teaching of Mendonça, Portela and Maciel Neto (2022), this model presents the novelty of allowing payment to the supplier while still in the experimental phase, which breaks with the traditional logic of public acquisition. In this context, the Administration's focus does not fall on the physical purchase of a device or machinery, but rather on the empirical validation that the proposed innovation is effective in solving the previously diagnosed administrative problem, prioritising practical usefulness and the performance of the solution over the mere possession of the material good.

The procedure allows the Administration to launch technological challenges and to contract *startups* through simplified processes, focused on results and feasibility tests, breaking with the previous rigidity of Law 8,666/1993. The delimitation of the scope of the bidding may be restricted to the indication of the problem to be solved and of the expected results, dispensing with the description of any technical solution previously mapped and its specifications, leaving it to the bidders to propose different means for solving the problem.

The winners conclude the CPSI, which allows the performance of remunerated tests in a real environment. Should the innovative solution prove successful, the Administration may conclude a supply contract, with limited term and values, with the proponent that achieves the established goals. This modality represents an important instrument of rapprochement between the public sector and emerging technology-based companies, promoting open innovation in the Public Administration (Portela, 2022).

Considering the current scenario of paradigmatic transition, this research has as its central purpose to analyse how Law No. 14,133/2021 and Complementary Law No. 182/2021 reorient the public procurement system in Brazil towards the encouragement of innovation.

For the development of this analysis, the study is grounded on the following specific objectives: to assess the operationality of the competitive dialogue and of the Public Contract for Innovative Solutions (CPSI) as paths for overcoming excessive bureaucratic formalism; to investigate the potentialities and limits of these new institutes in promoting technology transfer to the public sector; and to diagnose the main institutional challenges, such as the lack of technical expertise and the risks of technological dependence (*lock-in*), which may hinder the integration of new knowledge by the State. In this way, the aim is to verify the effectiveness of the current legal framework as an instrument for fostering innovation and for enhancing the administrative capacities of the State.

2 THEORETICAL FRAMEWORK

The theoretical foundation of this study rests on the analysis of the contemporary normative benchmarks that underpin the promotion of innovation in Brazilian public sector procurement. From this perspective, the transition from the regime established by Law No. 8,666/1993 to the 2021 legal framework reveals a fundamental paradigmatic rupture, in which the traditional model, of strictly formalist character, is superseded by a system that privileges administrative efficiency and technological promotion. In this context, the new legal apparatus seeks not only procedural modernisation, but the consolidation of an environment geared towards the enhancement of state capacities and the pursuit of more effective results for the collectivity.

2.1 INNOVATION IN LAW NO. 14,133/2021

The enactment of Law No. 14,133/2021, which took place on 1 April 2021, redesigned the panorama of state acquisitions by elevating innovation to the *status* of an express purpose of the tender. Through the interpretation of Article 11, item IV, and its sole paragraph, the promotion of sustainable national development and of technological progress become fundamental guidelines, requiring from the administrative structure more qualified planning and rigorous contractual monitoring. In this context, Aragão (2021) considers that this new legal framework overcomes the historical dichotomy between the public and private spheres, inaugurating an era of institutionalised collaboration.

The system introduced by the new legal diploma broadens legal certainty by consolidating mechanisms that encourage the public sector and create an environment favourable to innovation-based entrepreneurship. The State's significant economic power, reflected in the volume of its procurement, comes to act as a strategic lever for public policies focused on technical development. In view of the fluidity and complexity of the global

scenario, the Public Administration must not remain static; on the contrary, it must make use of public procurement as the necessary path for the renewal of institutions, meeting the demand for more agile, efficient services integrated with contemporary technologies (Freitas Jr., 2022).

However, for these general innovation guidelines to materialise into partnerships with technology-based companies, the Brazilian legal system was complemented by more specific rules. In this sense, it becomes indispensable to analyse how the Legal Framework for *Startups* dialogues with this new reality, instituting tailor-made instruments for technological experimentation in the public sector.

2.2 THE LEGAL FRAMEWORK FOR STARTUPS AND THE PUBLIC CONTRACT FOR INNOVATIVE SOLUTIONS (CPSI)

Although Law No. 14,133/2021 consolidated innovation as a fundamental guideline of the contemporary Public Administration, its practical application in disruptive technology markets lacked a set of rules that conformed to the reality of emerging companies. In this panorama, Complementary Law No. 182/2021, named the Legal Framework for *Startups*, is configured as an essential microsystem for giving effectiveness to the general bidding rules, providing the operational support indispensable so that the innovative mandate does not remain at the abstract level.

From the perspective of Novaes (2024), the aforementioned legislation structures the participation of *startups* along three fundamental axes: the definition of principles for administrative conduct, the stimulus to the capitalisation of the sector and the implementation of a debureaucratized bidding procedure. In this way, a strategic convergence between the normative frameworks is verified as they foster collaborative interaction between the State and private initiative, transforming the significant governmental purchasing power into a vector of development for products generated in innovation ecosystems.

However, it is imperative to observe the existence of a significant technical distinction regarding the concept of *startup*, because, whereas the general 2021 rules adopt a broad definition, anchored in the Statute of Micro and Small Enterprises, LC No. 182/2021 establishes more rigorous and specific requirements (Novaes, 2024). This conceptual density is fundamental for conferring the legal certainty indispensable to the use of instruments that involve experimentation and risk, such as the Public Contract for Innovative Solutions (CPSI), ensuring that the Public Administration may validate technological solutions in a real environment before an eventual large-scale acquisition.

The CPSI materialises a change of logic by authorising the Administration to carry out remunerated tests in real scenarios to assess the feasibility of technologies still in the maturation stage. Article 13 of the Legal Framework for Startups and Innovative Entrepreneurship (MLSEI) authorises the contracting of natural or legal persons for the performance of these tests, regardless of the degree of technological risk involved. As Mendonça, Portela and Maciel Neto (2022) explain, the core of the CPSI does not reside in the immediate patrimonial acquisition, but in the technical validation that the proposed solution has the capacity to solve the identified public problem:

a special contract that allows the Administration to contract tests to evaluate the performance of innovative solutions in a real environment. In an unprecedented manner, even during the tests, suppliers may be remunerated. Even if the innovative solution is a device or a machine, the object of the CPSI will not be the acquisition of the machine or the device, but rather the demonstration in a test environment that such an innovative solution solves the problem identified by the public administration. (Mendonça, Portela E Maciel Neto, 2022, p. 470-475).

In opposition to the classic bidding model, the CPSI institutionalises the so-called “technological neutrality”, since the Public Power limits itself to delimiting the problem and the desired results, transferring to the bidders the responsibility for proposing the most adequate technical solution. This logical inversion demands the adoption of multidimensional judgment criteria that go beyond the merely formal analysis. As Oliveira (2024) sustains, the selection must weigh the potential to resolve the challenge, the development stage of the proposal and the feasibility of the business model, even enabling the Administration to conclude multiple contracts simultaneously to address the same institutional bottleneck.

From the standpoint of public management, the CPSI acts as a true catalyst of transversal transformations, allowing the adaptation of technological solutions to generate innovations that transcend the contracted object itself and reach the very governance of the organisations involved. This process of institutional learning enables what Lana (2021) terms the incubation of emerging technologies within the state apparatus, promoting a technical maturing that benefits both the public and the private sector.

On the theoretical plane, the preliminary stages of this adjustment resemble pre-commercial agreements, aiming to mitigate critical gaps, such as the communication failure between buyers and suppliers and the historical exclusion of small companies holding embryonic solutions. Oliveira (2024) points out that this mechanism reduces the informational asymmetry and the risk aversion inherent to highly complex projects. In this way, the CPSI consolidates itself as a strategic instrument of public policy that prepares the legal ground so

that, after validation of the solution's effectiveness in a real environment, the State may advance with confidence towards the definitive contracting of the supply.

2.3 COMPETITIVE DIALOGUE: CONCEPT AND INTERACTION WITH THE MARKET

Whereas the Public Contract for Innovative Solutions (CPSI) prioritises celerity and technological experimentation in *startup* ecosystems, the competitive dialogue, introduced by Law No. 14,133/2021, is geared towards procurement of high technical or infrastructural complexity. This modality finds its genesis in European Law, notably in Directives 2004/18 and 2014/24 of the European Union, which recognised the need for more flexible procurement methods for the promotion of efficiency and sustainable growth (Pereira Neto; Pereira, 2024). Under the aegis of the previous regime, established by Law No. 8,666/1993, the Public Administration faced the paradox of needing to describe the object in minute detail even without knowing the technical solutions available in the market, which invariably generated inefficiencies and obsolescence.

For the concrete viabilisation of innovation by the public entity, the new bidding law brought, among its bidding modalities, the competitive dialogue, being a modality of procurement in which the Public Administration holds dialogues with selected bidders to develop alternatives that meet its needs. This modality is used in special situations where there is technological or technical innovation, and the Administration does not possess sufficient technical knowledge to specify the most adequate solution. The competitive dialogue provides interaction with market agents, in order to promote greater knowledge for the Administration, so that a notice may be drawn up with an objective description of the solution and the definition of the criteria that will be used for the selection of the proposal (Couto e Capagio, 2021).

Initially, the pre-selection of economic agents takes place, in order, at a second moment, to begin the debate phase properly. In this way, this structure allows the dialogue to develop in successive phases, gradually reducing the number of proposals until the solution that best satisfies the Administration's demands is identified, breaking with the rigidity of the traditional bidding model (Pereira Neto; Pereira, 2024).

The application of this modality is restricted and conditioned on the cumulative fulfilment of requirements established in art. 32 of Law No. 14,133/2021, such as: i) the presence of technological or technical innovation; ii) the impossibility of satisfying the need without the adaptation of market solutions; and iii) the Administration's incapacity to define the technical specifications with sufficient precision. As it is an exceptional bidding hypothesis, its choice must be technically motivated, demonstrating that the dialogue is the instrument that

best contemplates the public desire due to the disruptive nature of the object (TCU, 2024). Justen Filho (2021) warns that the innovative dimension of the dialogue requires the setting aside of traditional hermeneutic standards, adopting a more dynamic and flexible interpretation to embrace methods capable of meeting the complex and evolving demands of the public sector.

In practice, the procedure establishes that the Administration present its needs and requirements already defined, opening a minimum period of 25 working days for the expression of interest in participation. The pre-selected bidders participate in meetings recorded in minutes and audio-recorded, in which they develop one or more alternatives capable of meeting the Administration's needs. The dialogue phase may be maintained until the Administration identifies the adequate solution or solutions, there being the possibility of successive phases with progressive restriction of the solutions or proposals, according to the guidelines of the Federal Court of Accounts (TCU, 2024).

After the closure of the dialogues, the competitive phase begins with the disclosure of a notice containing the specification of the solution and the objective selection criteria, with a period of no less than 60 working days for the presentation of final proposals (TCU, 2024).

In sum, the legal system outlined by Law No. 14,133/2021 and by Complementary Law No. 182/2021 provides the normative support apt to allow the Brazilian Public Administration to mitigate the traditional bureaucratic formalism and to assume an inducing role in technological development. However, the doctrine and the administrative *praxis* show that legislative evolution, although indispensable, does not by itself ensure the conversion of the State into an effective facilitator of technology transfer.

From this standpoint, the functionality of institutes such as the Competitive Dialogue and the CPSI is intrinsically linked to the maturity of institutions in managing risks, reducing informational asymmetries and absorbing the technical knowledge originating from partnerships with the private sector. Thus, the understanding of how this legal potential is converted into practical results, as well as the identification of the institutional obstacles that still persist, demands a thorough investigation of the scientific and documentary production, whose methodological contours will be detailed in the subsequent section.

3 METHODOLOGY

The present research is guided by a qualitative approach of a bibliographic nature, structured with the purpose of investigating the transformations that occurred in the regime of Brazilian public procurement destined to foster innovation. In order to confer the

methodological rigour and reliability necessary to the findings, the procedures were organised into complementary stages of data collection and treatment.

In a first moment, a detailed normative analysis was carried out, with central focus on Law No. 14,133/2021 and on Complementary Law No. 182/2021, integrating this examination into a comprehensive doctrinal review on the axes of public innovation and technology transfer. The bibliographic universe comprised the study of legal frameworks, reference works, scientific articles and applied studies that specifically address the competitive dialogue and the Public Contract for Innovative Solutions (CPSI), in addition to the structural challenges for the absorption of new knowledge by the state apparatus.

As regards the treatment of the selected material, interpretive and comparative analysis was adopted, a method that allowed diagnosing the convergences, the limitations and the practical implications of the new legal institutes. Through this path, the aim was not only the description of the normative text, but the assessment of its applicability in the face of the complexity of contemporary administrative demands, mapping the institutional barriers that still obstruct the effective implementation of innovation in the Public Administration.

4 RESULTS AND DISCUSSION

4.1 THE OBSTACLES OF THE TRADITIONAL MODEL AND THE PARADOX OF THE STATIC OBJECT

From the perspective of the legislative evolution analysed thus far, it is imperative to recognise that the transition to the new bidding regime is grounded on the exhaustion of a model that became incompatible with the complexity and the dynamism of the contemporary market. The diagnosis of this failure is, essentially, of an institutional nature, as evidenced in the final report of the Modernisation Commission of the Federal Senate (CTLICON). The aforementioned document indicated that the effectiveness of Law No. 8,666/1993, although it represented a relevant milestone at its genesis, was not capable of promoting the necessary equalisation between the demands of the Administration and the reality of current technological solutions. In this sense, the excessive rigour of the rule frequently proved impractical or even unenforceable, which ended up generating a scenario of profound insecurity for managers and, in parallel, opened room for unfair conduct on the part of suppliers.

In this context of procedural limitations, such institutional rigidity culminated in a paradox of complex procurement. Under the reign of Law No. 8,666/1993, the Public Administration was frequently compelled to describe the object in minute detail while still in

the basic design phase, even in the face of the lack of knowledge of the most advanced technological alternatives available in the market.

This requirement of a static object disregarded the premise that, in projects of high technical density, the ideal solution must be built dialogically throughout the process. As a direct consequence, this anachronistic model fostered the occurrence of deserted biddings, failed tenders and an interminable succession of contractual amendments that sought, almost always without success, to adapt the legal instrument to the supervening technical reality (Novaes, 2024).

It is possible to note that the fragilities of the old Law No. 8,666/1993 become even more evident when we analyse cutting-edge technology sectors. From this standpoint, Pellegrini *et al.* (2017) emphasise that the previous model was incapable of keeping pace with the feedback cycles and the so-called technological “*loops*”, which are an intrinsic part of the process of innovating.

In projects of high complexity, the rule would need to act as a tool that would assist the State in extracting information essential for decision-making. However, the old set of rules failed by ignoring fundamental aspects, such as transaction costs and the very incompleteness of technological contracts, which, by their very nature, cannot be fully anticipated at the moment of contracting.

Aiming to overcome these obstacles, Novaes (2024) argues that the management of complex adjustments requires a broadening of managerial powers and, inevitably, a greater margin of freedom in procurement. This need for flexibilisation justifies the distancing from the procedural rigidity of the past, allowing the Public Power to launch technological challenges focused on practical results and functionality tests. By concentrating the scope of the tender on the delimitation of the problem and of the expected effects, the Administration dispenses with the detailed description of a prior technical solution, delegating to the participants the responsibility of proposing the paths and means necessary for the resolution of the state challenge.

To overcome these obstacles, the management of complex adjustments requires a broadening of managerial powers and greater freedom in procurement. This need for flexibilisation justifies the distancing from the procedural rigidity of the past, opening the way for the Public Power to use interaction with the market as an intelligence tool, a transition that materialises with the advent of Law No. 14,133/2021.

4.2 THE DIALOGIC TURN: LAW NO. 14,133/2021 AND THE COMPETITIVE DIALOGUE

With the aim of overcoming the rigidity that characterised the previous regime, Law No. 14,133/2021 consolidates the dialogic administration, replacing excessive formalism with a strategic interlocution between the State and private initiative. Under this new perspective, the dialogue with the private party ceases to be regarded with distrust in order to become an essential collaborative tool. This change of stance allows the Public Administration to mitigate the asymmetry of information and to identify, with greater clarity, the market solutions that are truly effective for the challenges of the public sector.

The competitive dialogue concretises this change of paradigm by acting as a refined instrument for the revelation of information for the Public Power. Whereas under the regime of Law No. 8,666/1993 the Administration was forced to establish the object unilaterally, the current legal system allows the state entity to present only its needs and the technological bottlenecks it intends to overcome, transferring to private initiative the burden of proposing technically feasible solutions.

From an innovative standpoint, Krieger *et al.* (2021) emphasise that this modality is also characterised as an alternative means for the resolution of conflicts within the administrative sphere. This mechanism ensures the manager an avenue of active interaction that, in times past, was restricted to institutes such as mediation or conciliation, strengthening consensuality and efficiency in the pursuit of the best public interest.

As Couto and Capagio (2021) point out, this interaction with market agents promotes superior technical knowledge for the Administration, allowing the drawing up of notices with objective descriptions and selection criteria aligned with the current technological reality. Procedurally, this transition requires the Public Administration to act as a mediator of innovative solutions, drastically reducing contractual uncertainties and transaction costs. The differential lies in the flexibility of the dialogue, which allows listening to the market before defining what to contract, ensuring that the final notice reflects real solutions and avoids technically inadequate proposals. According to Gonçalves and Torres (2025), the merit lies in the capacity to build alternatives jointly, extracting from the private sector a technical knowledge that the public entity often does not possess autonomously.

In this way, by breaking with the unilateral and static paradigm of traditional biddings, the new legal system allows the supplier market to be raised to the condition of strategic partner of the Administration. The competitive dialogue ceases to be understood as a simple avenue of acquisition in order to consolidate itself as an instrument of state intelligence, apt to enable the collaborative development of solutions that effectively meet the public interest. From this standpoint, the new dynamic of partnership in favour of innovation paves the way

for the application of even more flexible institutes, such as the Public Contract for Innovative Solutions (CPSI), whose focus falls primarily on experimentation and the management of technological risk in a real environment.

4.3 THE CPSI AND TECHNOLOGICAL EXPERIMENTATION

Unlike the Competitive Dialogue, which is geared towards large-scale infrastructure undertakings or systems of high complexity, the CPSI, instituted by Complementary Law No. 182/2021, privileges celerity and the experimentation of emerging technologies. Under this new logic, the solution submitted to the test may even be in the development stage, not yet being available for free commercialisation. In this sense, the absence of an exhaustive description of the object must not be interpreted as a technical deficiency of the Public Administration, but rather as a characteristic inherent to the very nature of the instrument, as the Office of the Attorney General of the Union (Advocacia-Geral da União) points out (2025). The introduction of the CPSI therefore configures a structural rupture with the traditional model, allowing the State to remunerate the execution of tests in a real environment and to evaluate the results in an incremental manner.

By enabling this dynamic, the CPSI integrates into administrative practice fundamental principles of innovation ecosystems, such as prototyping, iterative adjustments and learning by use. This legal arrangement redefines governmental strategies by transitioning from the stimulus focused on supply to the incentive oriented by demand. As Oliveira (2024) observes, this approach prioritises the creation of markets and incentives that make viable the effective adoption of the innovations produced, transforming the supplier market into an active agent in the construction of strategic solutions for the public interest.

The flexibilisation brought by the Legal Framework for *Startups* reduces the historical distance between public bodies and technology-based companies, favouring technology transfer through a continuous interaction between developers and managers during the validation phases (Mendonça; Portela; Maciel Neto, 2022). This process overcomes the classic limitations of Law No. 8,666/1993, which hindered the contracting of objects whose results were uncertain. By admitting technological risk and allowing its shared management, the CPSI broadens the state's capacity to participate in the development cycle, enabling incipient technologies to be incubated and improved within the public sector itself (Lana, 2021).

As regards technology transfer, the CPSI establishes mechanisms that allow the knowledge generated during the tests to be internalised by the Public Administration and, subsequently, converted into definitive supply contracts. The State comes to play an active

role in the conversion of experimental technologies into operational solutions, facilitating the transition between applied research and governmental adoption. In this way, the CPSI acts as a vector of permeability of the state apparatus to science and to innovative practices. However, it is imperative to recognise that the legal framework, on its own, does not guarantee innovation automatically, since its effectiveness still runs up against institutional barriers and cultural traits of the public service that resist new management models.

4.4 TECHNOLOGY TRANSFER AS A POSSIBLE, BUT NOT AUTOMATIC, RESULT

Public procurement geared towards innovation, operationalised through the CPSI and the Competitive Dialogue, reveals a singular capacity to transcend the limitations of traditional acquisition models, which frequently prove insufficient to meet the complex demands of contemporary society. However, the application of these institutes in the Brazilian scenario is still incipient, tending to concentrate on the optimisation of internal flows to the detriment of structural transformations of broad collective interest (Sousa e Vieira, 2025).

In this scenario, several obstacles impede the full advancement of innovation, such as the lack of technical competences, the lack of knowledge of the new legal frameworks and the scarce experience of public agents, who lack continuous and interdisciplinary training. Added to this picture is the fear of individual accountability, a sentiment that fosters a culture of self-protection and contributes to the phenomenon of the “apagão das canetas” (pen blackout). From the standpoint of Cunha (2026), the effectiveness of these modalities presupposes a careful implementation, supported by robust governance policies and the constant improvement of human capital.

Despite such obstacles, the 2021 legal system established the bases for technology transfer to occur through distinct paths. Within the scope of the CPSI, the transfer materialises through co-production, in which the monitoring of the tests in a real environment promotes an intensive exchange of knowledge between the state technical staff and the *startups*, allowing new solutions to be gradually assimilated as institutional learning. In the Competitive Dialogue, on the other hand, this process occurs through the making explicit of private knowledge, at which moment the bidders reveal technologies and technical limitations for the refinement of the object, which reduces the knowledge gap and allows the State to become familiar with emerging innovations even before the definitive contracting.

However, this learning only consolidates itself as internalised technology if the administrative structure possesses critical capacity to process such information. The legal literature shows that internal limitations constitute severe bottlenecks, since:

a good part of those who make up the body of servants of public entities is not qualified even to conduct a bidding process, let alone to identify the problem and to technically create a challenge to be overcome. More than that, the absence of regulation of the internal phase of the bidding procedure [...] ends up inhibiting its use in the face of the culture of self-protection and administrative complacency (Rezende, 2025, p. 46-47).

From another standpoint, one of the most critical risks in this process is the phenomenon of technological *lock-in*, a situation in which the Public Administration comes to depend excessively on a single supplier, compromising its decision-making autonomy (Narasimhan *et al.*, 2009). In the public sector, this entrapment occurs when the operation or the evolution of complex systems, such as Artificial Intelligence models or cloud services (SaaS), become restricted to the private partner (Soares, 2025). The lack of transparency in the algorithmic logic prevents the effective internalisation of knowledge, resulting in a worrying outsourcing of state intelligence.

In this way, although greater interaction with the market is necessary, it also broadens the risk of capture of public agents, in which the asymmetry of information may induce decisions that favour private interests to the detriment of the common good. Avoiding technological entrapment and capture requires the recognition that administrative modernisation does not amount to the mere acquisition of products, but to the construction of solid state capacities, grounded on open technical standards and on the preservation of digital sovereignty.

5 CONCLUSION

The analysis undertaken demonstrated that the normative innovations introduced by Law No. 14,133/2021 and by Complementary Law No. 182/2021 significantly reconfigure the space for innovation in Brazilian public procurement. The mechanisms of the Competitive Dialogue and of the Public Contract for Innovative Solutions (CPSI) respond to historical limitations of the traditional model, overcoming bureaucratic rigidity and the paradox of the static object that rendered experimentation and allocative efficiency unfeasible. By allowing a strategic and transparent interaction with the market, such instruments reduce the knowledge gap between the State and private initiative, broadening the state's potential for absorbing disruptive technologies.

However, the results show that technology transfer, although legally possible, is not an automatic result of legal validity. Severe institutional obstacles persist, such as the insufficiency of the servants' technical competences, the fear of individual accountability, the “apagão das canetas” (pen blackout), and the marked informational asymmetry. Furthermore, the risk of capture of public agents by private interests and the danger of technological

entrapment (*lock-in*) in proprietary models were identified, especially in solutions based on *Software as a Service* (SaaS) and artificial intelligence, which may compromise the State's digital sovereignty.

The investigation also revealed significant gaps in the academic debate and in administrative practice. It was verified that the use of these new frameworks is still incipient and frequently restricted to internal optimisations. Although the literature on the theoretical aspects of Law No. 14,133/2021 is vast, the production that empirically analyses how these instruments result in effective technology transfer, or how organisational culture impacts the mechanisms of institutional learning, is still reduced.

In view of this scenario, relevant paths for future research emerge, highlighting: (i) empirical studies on the implementation of these modalities in different federative spheres; (ii) the development of indicators of technological absorption by the Public Administration; (iii) investigations on data governance in AI procurement for the prevention of *lock-in*; and (iv) comparative analyses on the reduction of litigation after the adoption of dialogic rites.

It is concluded, therefore, that normative advancement is a necessary but not sufficient condition for transforming the State into an agent that induces innovation. The effectiveness of these instruments depends on continuous investments in human capital, institutional strengthening and a strategic governance geared towards transparency and integrity. Only with the overcoming of the barriers of state capacity will it be possible to convert the potential of the new laws into concrete, sustainable results, rigorously aligned with the public interest.

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STATE, BUSINESS AND INTEGRITY: THE PUBLIC-PRIVATE RELATIONSHIP AND THE SUSTAINABLE PUBLIC PROCUREMENT SYSTEM.

ESTADO, EMPRESA E INTEGRIDADE: A RELAÇÃO PÚBLICO-PRIVADO E O SISTEMA DE CONTRATAÇÕES PÚBLICAS SUSTENTÁVEIS.

ESTADO, EMPRESA E INTEGRIDAD: LA RELACIÓN PÚBLICO-PRIVADA Y EL SISTEMA DE CONTRATACIONES PÚBLICAS SOSTENIBLES.



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ABSTRACT

This article analyzes the structural transformation of Brazil's public procurement system driven by the convergence of State, business, and integrity as vectors of a new institutional architecture oriented toward sustainable development. It argues that sustainability—understood in its environmental, social, and economic dimensions—has moved beyond a merely programmatic guideline to become a binding legal norm and the central metric for assessing administrative performance, in direct alignment with the UN 2030 Agenda and, in particular, SDG 16, which calls for building effective, accountable, and transparent institutions at all levels. The study examines the normative trajectory from the 1988 constitutional foundations to the enactment of Law 14,133/2021, identifying the construction of new horizons that break with the bureaucratic-formalist model in favor of a managerial rationality focused on generating public value. It demonstrates how the State, through the strategic exercise of its purchasing power—which mobilizes approximately 15% of national GDP—assumes the role of catalyst for structural market transformations, inducing business practices aligned with ESG criteria, technological innovation, and corporate integrity programs. The research contends that integrity, far from constituting a mere formal compliance requirement, emerges as a structuring principle of a new ecosystem of public governance, operating simultaneously as a mechanism for risk mitigation, institutional trust-building, and alignment between public and private interests.

Keywords: Sustainable Public Procurement. National Sustainable Development. Corporate Integrity. State Purchasing Power. Law 14,133/2021.

RESUMO

Este artigo analisa a transformação estrutural do sistema brasileiro de contratações públicas a partir da interação entre Estado, empresa e integridade como vetores de uma nova arquitetura institucional orientada ao desenvolvimento sustentável. Aponta que a sustentabilidade – compreendida em suas dimensões ambiental, social e econômica – transcendeu sua condição de diretriz programática para consolidar-se como norma jurídica vinculante e métrica central de avaliação da performance administrativa, em alinhamento direto com a Agenda 2030 da ONU e, particularmente, com o ODS 16, que preconiza a construção de instituições eficazes, responsáveis e transparentes em todos os níveis. O estudo examina o percurso normativo desde os fundamentos constitucionais de 1988 até a promulgação da Lei 14.133/2021, identificando a construção de novos horizontes, rompendo com o modelo burocrático-formalista em favor de uma racionalidade gerencial focada na

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geração de valor público e na eficiência. Demonstra-se como o Estado, no exercício estratégico de seu poder de compra – que mobiliza aproximadamente 15% do PIB nacional –, assume papel de catalisador de transformações estruturais no mercado, induzindo práticas empresariais alinhadas aos critérios ESG à inovação tecnológica e aos programas de integridade corporativa. A pesquisa procura estabelecer que o desenvolvimento sustentável, aliado à integridade, longe de constituir mero princípio formal, emerge como fundamento estruturante de um novo ecossistema de governança pública, operando simultaneamente como mecanismo de mitigação de riscos, construção de confiança institucional e alinhamento entre interesses públicos e privados.

Palavras-chave: Contratações Públicas Sustentáveis. Desenvolvimento Nacional Sustentável. Integridade Corporativa. Poder de Compra Estatal. Lei 14.133/2021.

RESUMEN

Este artículo analiza la transformación estructural del sistema brasileño de contrataciones públicas a partir de la interacción entre Estado, empresa e integridad como vectores de una nueva arquitectura institucional orientada al desarrollo sostenible. Señala que la sostenibilidad —comprendida en sus dimensiones ambiental, social y económica— trascendió su condición de directriz programática para consolidarse como norma jurídica vinculante y métrica central de evaluación del desempeño administrativo, en alineamiento directo con la Agenda 2030 de la ONU y, particularmente, con el ODS 16, que preconiza la construcción de instituciones eficaces, responsables y transparentes en todos los niveles. El estudio examina el recorrido normativo desde los fundamentos constitucionales de 1988 hasta la promulgación de la Ley 14.133/2021, identificando la construcción de nuevos horizontes, rompiendo con el modelo burocrático-formalista en favor de una racionalidad gerencial centrada en la generación de valor público y en la eficiencia. Se demuestra cómo el Estado, en el ejercicio estratégico de su poder de compra —que moviliza aproximadamente el 15% del PIB nacional—, asume el papel de catalizador de transformaciones estructurales en el mercado, induciendo prácticas empresariales alineadas con los criterios ESG, la innovación tecnológica y los programas de integridad corporativa. La investigación busca establecer que el desarrollo sostenible, aliado a la integridad, lejos de constituir un mero principio formal, emerge como fundamento estructurante de un nuevo ecosistema de gobernanza pública, operando simultáneamente como mecanismo de mitigación de riesgos, construcción de confianza institucional y alineamiento entre intereses públicos y privados.

Palabras clave: Contrataciones Públicas Sostenibles. Desarrollo Nacional Sostenible. Integridad Corporativa. Poder de Compra Estatal. Ley 14.133/2021.

1 INTRODUCTION

Understanding the sustainable public procurement system requires, as a starting point, a genuine re-signification of the structuring concepts of State, business and integrity, for it is precisely in the friction—and cooperation—among these three poles that the possibility of public spending oriented toward the production of public value is decided. The State, traditionally conceived as a politico-legal organization dedicated to the realization of the common good, endowed with public-law personality and supported by the tripod of people-territory-sovereignty, is not merely a bureaucratic mechanism charged with “keeping” administrative procedures “moving”; it is, above all, a normative agent and inducer of public policies, holder of a peculiar capacity to create, apply and radiate the Law into social life. State action, especially when it mobilizes its purchasing power, projects itself beyond the procedural rite: it becomes a technology for constitutional implementation, capable of inducing conduct, reorganizing markets and signalling civilizational priorities.

Another tool inseparable from the full functioning of this mechanism concerns the business enterprise—which, under the terms of Article 966 of the Civil Code—is the organized economic activity, professionally conducted with a view to producing or circulating goods and services. This normative statement, although succinct, reveals a complex universe of the organization of factors of production, economic rationality and professionalism, so that the enterprise comes to operate as an essential node of the networks that connect investment, innovation, labour and consumption. In view of this, State and business do not figure as episodic antagonists confronting one another in bidding procedures, but as interlocutors within the same governance arena, co-participants in an economic and social cycle that demands coordination, predictability and reciprocal responsibility. It is precisely in this dialogic space that it becomes possible to move from the binomial “regulate and punish” to the logic of “plan, contract and deliver value”.

Integrity, in turn, plays the role of the normative-axiological axis of this arrangement. As Marcelo Zenker recalls, the concept can be read in the philosophical, legal, ethical and personal registers; for the present study, what matters above all is the legal-institutional dimension, in which integrity presents itself as an articulated set of principles, structures and practices that guide the conduct of agents and organizations. To be of integrity is to be whole—not split, not fragmented—and, within the scope of public procurement, this means aligning intention, procedure and outcome: preventing deviations, reducing information asymmetries, mitigating risks of capture, ensuring transparency and, ultimately, sustaining the legitimacy of the administrative decision before society. Integrity ceases to be a rhetorical

adornment and becomes a parameter of governance and a criterion for the quality of spending.

When projected onto the specific field of sustainable public procurement, these three elements—State, business and integrity—acquire singular relevance. It is not a matter of “yet another” procurement tool, but of a contracting axiom which, from its genesis, incorporates environmental, social and economic values as instruments for promoting national sustainable development.

State purchasing power, in this sense, becomes a vector of structural transformation: through technical specifications, judgment criteria, performance requirements, life-cycle cost analysis and the mitigation of negative externalities, the Administration does not merely acquire an object; it produces systemic effects, corrects market failures, disseminates technological standards and induces production chains toward cleaner and more inclusive trajectories. And this is not out of voluntarist zeal, but because the 1988 Constitution binds the economic order to social justice and sustainable development (Art. 170, VI) and elevates the ecologically balanced environment to the condition of a fundamental right (Art. 225), imposing duties of immediate—and not merely programmatic—protection.

In this key, the ecosystem of sustainable public procurement must be read as an interdependent network in which State, businesses, society and the environment are articulated according to a rationality of public value: price ceases to be the only guiding light, and “lowest cost” gives way to the “best outcome” for the true public interest.

The governance that emerges from this design is less hierarchical and more collaborative; it incorporates metrics that transcend immediate economics to measure social impacts, environmental value, responsible innovation and the dynamization of local economies. It is at this point that administrative law reveals its contemporary vocation: to execute the Constitution by way of management, a phenomenon that legal doctrine describes as the constitutionalization of administrative law and the administrativization of constitutional law—a two-way movement that brings principles and practices, principles and outcomes, closer together.

The Brazilian normative trajectory mirrors this inflection. The 1988 Constitution established the centrality of the environment and oriented the economic order by the vector of sustainable development; Law No. 8.666/1993, however, crystallized a strongly procedural model, with little openness to sustainability criteria. The maturing cycle began with statutes such as Law No. 12.305/2010 (National Solid Waste Policy) and the planning and budget commands that authorized socio-environmental parameters, gained muscle with Decree No. 7.746/2012 (which imposed sustainability criteria in procurement) and its infra-legal detailing

norms, and reached synthesis in the new framework of Law No. 14.133/2021, by reaffirming national sustainable development as a fundamental guideline of contracting and by redesigning instruments of planning, supplier selection and contractual execution. What was previously tolerated as “good practice” became due as a legal duty of conformation.

This path reveals the transition from a model centred on formal compliance and short-term economy to a paradigm of strategic, results-oriented contracting. The Administration ceases to be a clerk to become a manager: it plans on the basis of evidence, contracts by performance, monitors risks and assesses impacts. Considering that public acquisitions represent an expressive share of GDP, the way in which the State buys directly affects the country's development trajectory—whether to perpetuate negative externalities or to catalyse clean innovation, productive inclusion and resilient chains. The new standard requires adherence to the fundamental right to good administration, to efficiency as a duty and to the constitutional objectives of an economic, social and environmental nature, all densified into norms of immediate application.

In sum, sustainable public procurement does not constitute a peculiarity of administrative law, but a mechanism for constitutional realization that articulates State, business and integrity around a governance oriented toward public results. By integrating ESG criteria into the legal-administrative logic—without renouncing legality, impersonality and transparency—this model gives effectiveness to the 1988 constitutional project: to use public spending not only to acquire goods and services, but to produce, with probity and efficiency, a development that is simultaneously economically, socially and environmentally sustainable.

2 DIMENSIONS OF DEVELOPMENT AND SUSTAINABLE PUBLIC PROCUREMENT

The concept of sustainable development, by inseparably integrating the environmental, social and economic dimensions, has become the foundation for the reconfiguration of public procurement in Brazil. The country has developed one of the most comprehensive normative frameworks in the world for this purpose, in a process that was consolidated progressively. Law No. 12.349/2010 inaugurated a paradigm shift by amending Law No. 8.666/1993, including national sustainable development as an objective of bidding processes.

Decree No. 7.746/2012 deepened this perspective by establishing specific criteria and practices, creating the Inter-Ministerial Commission on Sustainability in Public Administration (CISAP). Normative Instruction SLTI/MP No. 01/2010, in turn, was pioneering in making the inclusion of environmental criteria mandatory in the technical specifications of all federal

contracts, anticipating what the New Law on Bidding and Contracts (Law No. 14.133/2021) would come to enshrine by elevating sustainability to the condition of a fundamental principle (Art. 5) and strategic objective (Art. 11, IV) of contractual activity. As Marçal Justen Filho aptly observes,

Law No. 14.133/2021 represents a regulatory milestone that not only updates the regime of administrative contracting but, above all, promotes sustainability to the legal level of a structuring principle, binding State activity to purposes of economic and socio-environmental development that transcend the merely procedural logic. (JUSTEN FILHO, 2022, p. 115).

This normative framework was recently expanded by Decree No. 11.890/2024, which created the Inter-Ministerial Commission on Public Procurement for Sustainable Development (CICS), significantly strengthening the institutional capacity of the State. The decree provides for preference margins of up to 10% for national products and up to 20% for innovation-based products, in addition to establishing criteria for the acquisition of recycled, recyclable or biodegradable goods.

Decree No. 11.890/2024 regulates Article 26 of Law No. 14.133/2021 and institutes the Inter-Ministerial Commission on Public Procurement for Sustainable Development (CICS), conceiving it as a governance unit devoted to the strategic use of State demand, with competences to propose and decide on preference margins (normal and additional), compensatory measures and sustainability criteria, among other instruments (Arts. 1, 7 and 8). Portal da Câmara dos Deputados. In operational terms, the decree sets a normal preference margin of up to 10% for national manufactured goods and services (compared to foreign ones) and, for the first time, extends the logic to recycled, recyclable or biodegradable goods; the additional margin, applicable to national goods/services resulting from technological development and innovation in the country, may be added to the normal one, subject to the ceiling of 20% (Art. 3, caput and § 1 in conjunction with Art. 2, I and II).

The act also provides for federative adherence: States, the Federal District, Municipalities and other Branches may adopt the margins defined by the federal Executive (Art. 3, § 4), which reinforces the inducing capacity of public purchasing power by expanding the scale and predictability of the policy. Portal da Câmara dos Deputados. This design executes the legal command of Article 26 of Law No. 14.133/2021, which authorizes margins for (i) national manufactured goods and services that meet Brazilian technical standards and (ii) recycled, recyclable or biodegradable goods, leaving to the federal regulation the definition of parameters and limits. Portal da Câmara dos Deputados. In interpretive reinforcement, the

TCU systematizes that the additional margin (innovation) accumulates with the normal one up to a maximum of 20%, consolidating the reading adopted by the Decree.

On the level of the manager's duties, Opinion No. 01/2021/CNS/CGU/AGU established the obligation to insert sustainability criteria and practices in all phases of contracting (planning, supplier selection, execution and oversight) and determined that non-adoption must be expressly justified in the records, with reasons of fact and/or of law—guidance that has been reiterated in official guides. *Serviços e Informações do Brasil*. Such an opinion dialogues with the constitutional-legal framework and with the guideline that sustainable bidding is the rule, whereas its waiver requires qualified justification. As Juarez Freitas observes:

The Public Administration, at all its levels, not only may but must exercise its purchasing power as an instrument to induce sustainable standards of production and consumption, so as to fulfil the constitutional duties of environmental protection, social justice and economic development. The rule is the adoption of sustainability criteria in all phases of contracting; the exception, duly justified, is their non-application. The public manager who omits this duty incurs a violation of the principle of efficiency and, even more, an affront to the Constitution itself, which requires of the Administration choices oriented toward the promotion of the common good in an intergenerational perspective” (FREITAS, 2016, p. 89).

Moreover, the Nova Indústria Brasil (NIB/2024) made explicit the use of public procurement as an instrument of industrial policy, and the government announcement of 22.01.2024 recorded, indeed, the signing of the decrees that create the CICS and define preference margin criteria for national goods/services and for recycled/recyclable/biodegradable goods, integrating the neo-industrialization policy into innovation and ecological transition strategies. *Serviços e Informações do Brasil*. The framework was refined by Decree No. 12.218/2024, which amended Decree No. 11.890/2024 and detailed attributions and references to the CICS resolution for the specification of eligible items, preserving the percentages and the logic of application.

In this same spirit, CGU Opinion No. 01/2021 made the adoption of sustainability criteria mandatory, imposing on the manager the duty to expressly justify their non-application. More recently, the integration of sustainable contracting into the Nova Indústria Brasil (2024) policy came to position the State's purchasing power as a strategic instrument of industrial policy and sustainable development.

The environmental dimension of public procurement is translated into specific and measurable criteria. It establishes, for example, the mandatory nature of energy efficiency, with the use of LED lamps and automation systems by presence sensors, as well as the

adoption of individualized consumption metering. Waste reduction becomes an essential requirement, imposing separation at the source, allocation to waste-picker cooperatives, pursuant to Decree No. 5.940/2006, and the use of recycled aggregates whenever available. Further required is the use of renewable, recycled, non-toxic and biodegradable materials, in conformity with ABNT NBR 15448, in addition to proof of the sustainable origin of wood and the prioritization of locally produced inputs.

The carbon footprint emerges as a tie-breaking criterion in bidding processes, valuing companies that demonstrate effective mitigation, in accordance with the National Policy on Climate Change. In this context, certifications such as ISO 14001 (environmental management), LEED and AQUA-HQE (sustainable buildings), FSC (timber products) and INMETRO (energy efficiency) are incorporated as validation elements, alongside objective performance indicators, such as energy consumption (kWh/m²), water consumption (litres/m²), the percentage of recycled materials used and CO₂-equivalent emissions.

The social dimension², in turn, aims at inclusion and dignity at work. It requires the provision of personal protective equipment, the delivery of sustainability training within the first three months of the contract, and full compliance with labour legislation. The Quota Law (Law No. 8.213/1991) imposes the reservation of 2% to 5% of jobs for persons with disabilities, depending on the size of the company, while gender-equality and non-discrimination policies become recurrent requirements. Support for micro and small enterprises is also guaranteed, in accordance with Complementary Law No. 123/2006, through differentiated treatment and specific preference margins. Certifications such as SA8000 and ABNT NBR 16001 attest to social responsibility, adding to those of accessibility and safety at work. Among the relevant social indicators are the percentage of employees with disabilities, the rate of work accidents, the diversity and inclusion index, the participation of ME/EPP in contracts and the level of worker satisfaction.

In the economic sphere, sustainability manifests itself through the logic of long-term value, by means of the full life-cycle analysis of the goods and services contracted. This assessment goes beyond the initial acquisition price to consider costs of use, maintenance, disposal and environmental externalities. The total cost of ownership (TCO) perspective strengthens the pursuit of long-term economy, while the local economic development policy

² The social dimension of sustainability in public and private procurement refers to the set of practices that promote social justice, labor rights and the inclusion of historically marginalized groups. This involves compliance with legal obligations, such as the Quota Law (Law No. 8,213/1991), which mandates the hiring of persons with disabilities, and the observance of standards that ensure decent working conditions, equal opportunities and support for small businesses. Certifications such as SA8000 (focused on social responsibility in the workplace) and ABNT NBR 16001 (aimed at social responsibility management) function as seals of good practices. The indicators mentioned allow assessing the social impact of contracts and the effectiveness of the policies adopted.

privileges regional suppliers, generates jobs and strengthens the national production chain. In addition, innovation criteria are incorporated, rewarding investments in research and development, the adoption of clean technologies and sustainable solutions. Within this framework, cost-benefit analysis comes to incorporate not only financial aspects, but also environmental and social costs, reinforcing the return on sustainable investment.

In a complementary manner, emerging dimensions have been incorporated into the concept of sustainability in public procurement³. Cultural sustainability orients the protection of historical heritage and the appreciation of local traditions; institutional sustainability⁴ strengthens governance, transparency and social participation; and technological sustainability promotes the adoption of clean technologies, the transfer of knowledge and the fight against planned obsolescence.

Sustainable development, when applied to public procurement, comes to demand an administrative action guided by good faith, legality and efficiency, breaking with the mechanistic thinking that reduced the bidding process to the pursuit of the lowest price. This view proves insufficient in the face of the constitutional mandate of national sustainable development, which requires effective results in the promotion of social justice, environmental preservation and economic balance. In this sense, as Maria Sylvia Zanella Di Pietro recalls:

The administrative contract cannot be understood as a mere formal arrangement intended to meet the immediate needs of the Administration. It is embedded in the realization of public purposes and, therefore, must be interpreted as an instrument for the realization of constitutional values. In the current context, the principles of efficiency, legality and good faith must be read in the light of the requirement of sustainability, so that the bidding procedure and the contractual execution are oriented not only toward the lowest price, but toward the most advantageous result in social, environmental and economic terms (DI PIETRO, 2022, p. 231).

In this sense, the administrative contract ceases to be an isolated act and comes to be configured as a genuine instrument of public policy, forming part of the structure of State governance. In the different phases of contracting—planning, selection of proponents and contractual execution—sustainability becomes a parameter of assessment. In planning,

³ On the cultural dimension as a vector of development and heritage protection: see CF/1988, art. 216 (protection of Brazilian cultural heritage) and the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (2003) and the Convention on the Protection and Promotion of the Diversity of Cultural Expressions (2005), incorporated into Brazilian law. Cf. BRASIL. Constitution (1988). Art. 216; UNESCO. Convention for the Safeguarding of the Intangible Cultural Heritage, 2003; UNESCO. Convention on the Protection and Promotion of the Diversity of Cultural Expressions, 2005.

⁴ Regulatory framework of public governance and its connection with procurement: Decree No. 9,203/2017 (Federal Public Administration Governance Policy) and Law No. 14,133/2021, arts. 5 (principles) and 11 (objectives), which integrate efficiency, transparency and results into the procurement regime. Cf. BRASIL. Decree No. 9,203, of Nov. 22, 2017; BRASIL. Law No. 14,133, of Apr. 1, 2021, arts. 5 and 11.

market analysis and the definition of socio-environmental conditioning factors are required; in selection, judgment criteria aligned with national sustainable development are employed; and, in execution, continuous monitoring of the fulfilment of socio-environmental goals is implemented.

This process also imposes the centrality of integrity as a constitutive element of sustainable public procurement. Institutional integrity corresponds to the commitment to ethical standards, transparency and the fight against corruption, which becomes even more relevant in the face of the complexity and legal risks added by sustainability. In this context, the integration of compliance mechanisms, documentary control and auditing reduces fraudulent practices, strengthens trust and ensures the effectiveness of environmental and social conditioning factors. A robust integrity system guarantees publicity, prevents conflicts of interest and unlawful steering, and expands control, both internal and external, becoming an essential condition for the reliability and legitimacy of sustainable public procurement.

2.1 THE STATE AS AN AGENT OF DEVELOPMENT: THE PURCHASING ENTITY AND THE PROMOTION OF SUSTAINABILITY AND INTEGRITY

The Brazilian State assumes, in the 1988 constitutional design, a function that transcends the mere regulation of social relations to configure itself as an active protagonist of national development. This transformative vocation is inscribed unequivocally in Article 3 of the Federal Constitution, which establishes as fundamental objectives of the Republic the construction of a free, just and solidary society, the guarantee of national development, the eradication of poverty and the reduction of social and regional inequalities. As Eros Roberto Grau observes:

The economic order is not limited to imposing negative restrictions on the market, but translates a normative project that assigns to the State an active role in shaping social and economic reality. The 1988 constitutional text inserts national development, social justice and the defence of the environment as purposes that bind all State action, especially economic activity. It is, therefore, a system of binding vectors that require of the State an inducing and transforming behaviour, compatible with the centrality of its function as a normative agent and regulator of economic activity (GRAU, 2010, p. 213).

This normative architecture does not represent a mere declaration of programmatic intentions, but establishes binding vectors that must orient all State action, especially in the exercise of its purchasing power, which moves approximately 15% of the national Gross Domestic Product.

The constitutional economic order, delineated in Article 170, reinforces and specifies this transformative mandate by establishing that economic activity, founded on the

valorization of human labour and on free enterprise, has the purpose of ensuring for all a dignified existence, in accordance with the dictates of social justice. The principles of the social function of property, of the reduction of regional and social inequalities, and of the defence of the environment—the latter qualified by differentiated treatment according to the environmental impact of products and services—do not constitute mere limitations on the exercise of economic activity, but positive guidelines that must be actively promoted by the State in all its manifestations, particularly through its public procurement.

The strategic role of the State as the largest single buyer in the Brazilian economy confers upon it a power of behavioural inducement that no traditional regulatory policy would be capable of achieving with the same effectiveness.⁵ When the public power establishes sustainability criteria in its bidding processes, it is not merely buying environmentally adequate products or services; it is signalling to the entire market a direction of development, creating demand at scale for sustainable products, incentivizing technological innovation and altering the very cost structure of the economy.⁶ As Teresa Villac Pinheiro Barki observes, “the State, by exercising its purchasing power with sustainability criteria, transforms itself into a vector of cultural and economic change, inducing practices that transcend the specific object of the contract to permeate the entire national production fabric.”

The transition from the bureaucratic-formalist model to a results-oriented paradigm represents one of the most profound transformations in contemporary Brazilian administrative law. Article 11, item IV, of Law 14.133/2021, by establishing as an objective of the bidding process “to ensure the selection of the proposal apt to generate the most advantageous contracting result for the Public Administration, including with respect to the life cycle of the object”, definitively breaks with the procedural logic that historically characterized Brazilian public procurement.⁷ It is no longer a matter of following bureaucratic rituals with formal perfection, but of achieving concrete results that add public value and contribute to the attainment of constitutional objectives.

This paradigm shift finds a powerful synthesis in the assertion of Camelo and Nóbrega (2024): “Democracy has to work”. The phrase, in its apparent simplicity, encloses a profound critique of the sterile formalism that for decades characterized Brazilian public administration. It is not enough for procedures to be formally legal; it is imperative that they produce effective

⁵ The specialized literature and OECD reports show that public procurement spending accounts, on average, for 12% to 15% of countries' GDP, granting the State undeniable power of economic and social inducement.

⁶ This multiplier effect is also highlighted by the TCU, which treats sustainable procurement as a public policy instrument capable of reordering markets and encouraging innovation.

⁷ BRASIL. Law No. 14,133, of April 1, 2021. Public Procurement and Administrative Contracts Law. Diário Oficial da União: section 1, Brasília, DF, Apr. 01, 2021. Available at: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/L14133.htm. Accessed on: Sept. 23, 2025.

results, that they deliver value to society, that they transform public resources into collective well-being. Legality, in this context, ceases to be an end in itself to become an instrument at the service of effectiveness. As the authors complement, “the legitimacy of the contemporary State does not derive solely from the formal fulfilment of norms, but from its capacity to deliver results that concretely improve the lives of citizens.”

The challenge of this transition of thought lies precisely in overcoming a secular administrative culture, forged under the aegis of patrimonialism and formalism as a mechanism of defence against corruption and arbitrariness. Public managers, trained in a tradition that values process over result, face the dilemma of assuming calculated risks in the name of effectiveness without compromising administrative probity. As Diogo de Figueiredo Moreira Neto points out:

The transition from bureaucratic administrative law to the administrative law of effectiveness demands not only normative adjustments, but a genuine cultural change in the Public Administration. The public interest can no longer be interpreted as a static and fragmented concept; it reveals itself as dynamic, intertemporal and systemic, requiring public managers to consider the impacts of their choices in multiple dimensions—economic, social and environmental—and across multiple temporal horizons. This reconstruction of the public interest, in a holistic key, is an indispensable condition for the State to fulfil its constitutional function as an agent of sustainable development” (MOREIRA NETO, 2016, p. 47).

Control bodies, in turn, are faced with the need to develop new assessment metrics that capture not only procedural compliance, but the real impact of public procurement on sustainable development indicators.

The operationalization of the State as an agent of sustainable development through public procurement is faced with structural obstacles that cannot be minimized. The first of these is the decisional fragmentation of the Administration, in which bodies and entities pursue sectoral objectives without measuring the systemic and intertemporal effects of their choices—including negative externalities that, although invisible to the contracting centre, burden the public treasury in other public policies or impact society as a whole⁸. Overcoming this scenario is not exhausted in administrative coordination: it requires a legal reconstruction of the public interest in a holistic and intertemporal key, compatible with the fundamental objectives of the Republic (Art. 3, CF/1988), with the principles of the economic order (Art. 170, caput and VI) and with the fundamental right to the environment (Art. 225), so as to

⁸ BRASIL. Federal Court of Accounts. Referencial de Governança para o setor público. Brasília: TCU, 2014 (subsequent updates). See also: SUNDFELD, Carlos Ari. *Direito Administrativo para Céticos*. 2nd ed. São Paulo: Malheiros, 2017

orient purchasing power toward the maximization of public value in the life cycle of the contracted object.

Next, the tension between standardization and flexibility emerges. If, on the one hand, standardizing specifications, judgment criteria and executive clauses reduces transaction costs, generates scale and raises legal certainty, on the other, adaptation to local and sectoral realities is a condition of the effectiveness of sustainable development: what is optimal for a metropolis may be inefficient or disproportionate in a small municipality.⁹ Law No. 14.133/2021 densifies this balance by positivizing sustainability as a principle (Art. 5) and objective of the bidding process (Art. 11, IV), opening space for judgment criteria oriented toward performance, innovation and life-cycle analysis (LCC/TCO), without abdicating isonomy and competitiveness. The literature on public governance and the TCU Governance Framework converge toward this design: standardize what pertains to management and make flexible what pertains to result, with verifiable indicators and risk management.

Technical capacity-building is a critical variable of this arrangement. The assessment of proposals from the standpoint of sustainability and added public value presupposes competences that transcend the strictly legal: life-cycle analysis, carbon footprint, circular economy, social metrics and methods of measurement and verification (M&V). As Juarez Freitas warns, the multidimensional sustainability of contracting demands interdisciplinary training of public agents, integrating legal, economic, environmental and social knowledge, oriented toward the common good. At this point, technical standards (e.g., ISO 20400 – Sustainable Procurement and ISO 14001 – Environmental Management Systems) and the Brazilian infra-legal record (Decree No. 7.746/2012; Normative Instructions on sustainable procurement) provide objectively auditable methodological roadmaps.

Finally, cultural resistance to change—expressed in risk aversion and in the reflex of the “lowest price” as a safe harbour—constitutes a real obstacle. The fear of personal accountability still induces defensive choices, even when there are more advantageous proposals on a life-cycle basis. The legal order, however, protects responsible technical discretion: the LINDB (Arts. 20, 22 and 28), reinforced by Decree No. 9.830/2019, requires consequentialist reasoning, prohibits abstract control decisions and establishes that the agent is only personally liable for fraud or gross error, which stimulates decisions qualified by evidence, and not immobilism. The risk matrix—consolidated in Brazilian law since Law No. 11.079/2004 (Art. 5, III) and disseminated in contracting in general—, allied to integrity programmes (required in large-scale contracts by Law No. 14.133/2021, Art. 25, § 4), aligns

⁹ CAMINHA, Ubirajara; and VILLAC, Teresa (eds.). *Contratações Públicas Sustentáveis*. Brasília: IPEA/CGU, 2012. (They highlight a regulatory design that allows contextual solutions without breaching equal treatment).

incentives, reduces uncertainties and mitigates litigiousness, making legally viable an action oriented toward results and sustainable public value.

Paradoxically, it is precisely in the conscious and reasoned exercise of discretion that the possibility of transformation resides. The choice among different proposals that meet the minimum requirements of the notice, privileging the one that best contributes to the objectives of sustainable development, does not constitute arbitrariness, but the legitimate exercise of the administrative function oriented by constitutional principles¹⁰. As Marçal Justen Filho sustains, “administrative discretion, when exercised on the basis of technical criteria and oriented by constitutional principles, is an indispensable instrument for the realization of the public interest in its contemporary acceptance.”

The role of the State as an agent of sustainable development materializes in a particularly eloquent manner in large-scale contracts, where the impact of public choices reverberates throughout the entire production chain.¹¹ The construction of an infrastructure work, for example, should not be assessed only by its direct cost and immediate functionality, but by its potential to induce regional development, generate qualified jobs, transfer technology and minimize environmental impacts.¹² This holistic vision demands a revolution in the methods of planning and assessment of public procurement, replacing the one-dimensional analysis of price with the multidimensional assessment of value.

International experience offers valuable lessons on the transformative potential of sustainable public procurement. Countries such as South Korea and Germany demonstrate that the strategic use of State purchasing power can accelerate the transition to a low-carbon economy, stimulate technological innovation and reduce regional inequalities. However, as Carlos Ari Sundfeld warns, “the uncritical importation of foreign models ignores the specificities of the Brazilian context, marked by profound inequalities and territorial diversity that demand its own creative solutions.”¹³

The consolidation of the State as an agent of sustainable development, through its capacity to contract and to discipline markets via purchasing power, represents, in the final analysis, the very teleological realization of the 1988 constitutional project. It is not a matter of episodic adherence to managerial fads, nor of administrative voluntarism; it is a legal-

¹⁰ Contemporary doctrine emphasizes that discretion has ceased to be a space for arbitrariness and has come to be delimited by constitutional principles, especially efficiency, legality and sustainability.

¹¹ The Federal Court of Accounts (TCU) has already recognized that high-value contracts must be planned in order to generate positive externalities, such as innovation, regional development and environmental sustainability.

¹² This understanding is aligned with art. 11, IV, of Law No. 14,133/2021, which introduces the criterion of life cycle analysis of the object as part of the advantagefulness of the contract.

¹³ SUNDFELD, Carlos Ari. *Direito administrativo para céticos*. 4th ed. São Paulo: Malheiros, 2020. Available at: <https://www.editoramalheiros.com.br/produto/direito-administrativo-para-ceticos/>. Accessed on: Sept. 23, 2025.

constitutional imperative that emanates, simultaneously, from the fundamental objectives of the Republic (reduction of inequalities, promotion of national development, construction of a free, just and solidary society) and from the principles of the economic order (valorization of labour, free enterprise, social function and sustainable development), in addition to the fundamental right to the ecologically balanced environment as a good of common use of the people and essential to a healthy quality of life.

From this perspective, contractual activity ceases to be seen as a bundle of isolated bureaucratic acts and comes to be understood as public policy in action, which must be planned, instructed, judged and executed in a manner coherent with the effectiveness of results required by the Constitution and by Law No. 14.133/2021—this, in turn, positivizing sustainability as a principle (Art. 5) and advantageousness by life cycle as an objective of the bidding process (Art. 11, IV).¹⁴

Indeed, democracy that works—paraphrasing the contemporary critique of sterile formalism—is the one that transforms legality into measurable public value, through decisions motivated by evidence, analysis of intertemporal costs and benefits, internalization of externalities and optimal allocation of risks. State purchasing power appears, in this context, as an economic-legal instrument of exceptional inducing potential: by structuring notices with sustainable technical specifications, performance-based judgment criteria and contractual integrity obligations, the State signals shadow prices, alters incentive structures and reorganizes production chains, producing results that pure ex ante regulation could hardly achieve with equal capillarity, allocative efficiency and democratic legitimacy. For this reason, advantageousness is not to be confused with the “lowest nominal price”; the calculation of the total cost of ownership (TCO) and of life-cycle analysis (LCC) is imposed, compatible with the economics of public contracting and with international best practices (OECD/European Union/ISO 20400), as well as with the governance by indicators advocated by the TCU.

The LINDB—as worded by Law No. 13.655/2018—reinforces this paradigmatic shift by requiring consequentialist reasoning (Art. 20), assessment of the practical impacts of administrative and control decisions (Art. 21), gradation of sanctions and the duty to consider the circumstances of the case (Art. 22), in addition to establishing that the public agent is not liable for mere reasonable interpretation and only for fraud or gross error (Art. 28). Far from

¹⁴ As Ronny Charles Lopes de Torres states: Public procurement, especially after the enactment of Law No. 14,133/2021, can no longer be understood as merely bureaucratic administrative procedures or as isolated acts of the Administration. On the contrary, it must be viewed as genuine public policies in execution, capable of inducing economic and social behaviors, promoting innovation, protecting the environment and realizing constitutional values. The bidding process ceases to be an end in itself and comes to constitute a means to achieve results that represent the maximization of public value, which requires integrated planning, adequate preparation and constant monitoring of contract execution (TORRES, 2022, p. 87).

stimulating recklessness, this regime protects responsible technical discretion, disincentivizes irrational risk aversion and frees decisional capacity so that the manager may opt for more advantageous solutions in the life cycle—even if they are not those of the lowest immediate price—provided they are duly reasoned, proportionate and auditable. The Governance Policy of the Federal Public Administration (Decree No. 9.203/2017), alongside Decree No. 9.830/2019 (which regulates provisions of the LINDB), converges toward robust planning, risk management, active transparency and accountability as conditions of the legitimacy of public spending.

Within this framework, integrity is not a bureaucratic appendage, but a condition of possibility of the model. Law No. 14.133/2021, by admitting/requiring integrity programmes in large-scale contracts (Art. 25, §4), institutionalizes¹⁵ the alignment of incentives between the Administration and private parties, reduces information asymmetries, mitigates legal-reputational risks and strengthens the legitimate trust indispensable to cooperative execution. In parallel, the risk matrix—of inspiration consolidated in the PPP Law (Art. 5, III) and disseminated in the general regime—objectifies responsibilities, establishes rebalancing triggers and distributes risks to those who can best manage them, increasing contractual efficiency and reducing litigation and opportunistic amendments. When associated with verifiable metrics (environmental, social, governance and economic), with performance-based payments (*bonus-malus*) and with independent auditing, such tools operationalize the constitutional promise of sustainability and good administration.

2.2 THE ENTERPRISE AS A STRATEGIC PARTNER IN THE GENERATION OF PUBLIC VALUE

The relationship between State and enterprise in public procurement is going through a moment of profound re-signification, marked by the definitive overcoming of the reductionist logic of the lowest price as the predominant decisional criterion.¹⁶ This paradigmatic transformation reflects the institutional maturing that recognizes in the enterprise not a mere supplier subordinated to State designs, but a strategic partner in the construction of public value. The valorization of ESG (Environmental, Social and Governance) criteria and of corporate social responsibility emerges as a structuring element of this new contractual architecture, where the metric of success transcends the immediate economy of resources

¹⁵ Article 37, caput, of the Federal Constitution of 1988 requires the Public Administration to respect the principles of legality, impersonality, morality, publicity and efficiency, which were expanded by the new Procurement Law to encompass sustainability as an interpretive vector.

¹⁶ Contemporary Administrative Law literature has emphasized that the focus on "lowest price" compromises the efficiency and advantageousness of the contract, out of step with the constitutional objectives of sustainable national development.

to encompass the systemic impact of the contract on the socio-economic and environmental fabric.¹⁷

This evolution finds its most forceful normative expression in Article 25, §4, of Law 14.133/2021, which establishes the requirement of integrity programmes for large-scale contracts. Such a provision represents more than an additional bureaucratic imposition; it is configured as legal recognition that corporate integrity constitutes an element inseparable from good contractual execution and, by extension, from the very legitimacy of the public-private partnership. The integrity programme, in this context, operates as a mechanism for alignment between public values and business practices, creating a zone of ethical convergence where private interest and the common good not only coexist, but mutually reinforce one another.¹⁸ The legal requirement induces companies to internalize controls and practices that, in protecting the Public Administration from deviant conduct, simultaneously strengthen the enterprise's own sustainability in the long term.

Expectations of business conduct in the new ecosystem of public procurement expand to encompass three fundamental and interdependent dimensions: ethics, innovation and sustainability.¹⁹ The ethical dimension transcends the mere formal fulfilment of contractual obligations to require a proactive posture of transparency, accountability and commitment to republican values. Innovation ceases to be an optional competitive differential to become a requirement for qualified participation in the public market, demanding from companies the capacity to propose creative solutions to the complex challenges of the contemporary Administration. Sustainability, in turn, consolidates itself as a transversal criterion that permeates from the conception of products and services to the methods of production and the relations with the supply chain, reflecting the constitutional imperative of national sustainable development.

The concept of the “citizen enterprise” emerges in this context as a synthesis of this new corporate identity demanded by the public market. It is not a rhetorical figure or an institutional marketing strategy, but a legal-administrative recognition that the enterprise, in contracting with the State, assumes co-responsibility for the attainment of public objectives. As Juarez Freitas points out:

¹⁷ Recent studies show that ESG criteria already impact investment decisions and trust in the private sector, a phenomenon that is also reflected in contractual relations with the public authorities (OECD, 2020).

¹⁸ In this regard, the doctrine of Floriano de Azevedo Marques emphasizes that integrity is a constitutive vector of contractual legitimacy, insofar as it ensures convergence between public values and private practices.

¹⁹ This triad of ethics–innovation–sustainability has been internationally recognized as a central criterion for strengthening strategic public procurement.

The contemporary enterprise, especially that which contracts with the Public Power, cannot restrict itself to the logic of immediate profit, nor to the merely formal fulfilment of its contractual obligations. It is called to assume a citizen identity, understanding that its economic success is inextricably linked to the promotion of the sustainable development of the collectivity. The so-called 'citizen enterprise' emerges as a subject co-responsible for the realization of fundamental rights, and must structure itself in practices of ethical governance, in policies of corporate social responsibility and in consistent environmental strategies. It is a revolution in the theory of the enterprise, whereby the maximization of private value is only legitimated when linked to the maximization of public value, in an intergenerational perspective (FREITAS, 2019, p. 211).

The citizen enterprise is characterized by the understanding that its economic success is intrinsically linked to the development of the society in which it operates, by the adoption of governance practices that mirror the principles of public administration, and by the commitment to the generation of positive externalities that extrapolate the specific contractual object. This conception implies a revolution in the very theory of the enterprise, which comes to incorporate into its decisional core considerations traditionally alien to pure mercantile logic.

The operationalization of this new paradigm faces, naturally, significant tensions and challenges. The valorization of ESG criteria and of social responsibility frequently implies additional costs that, in a superficial analysis, could appear contrary to the principle of economy. However, the sophisticated understanding of this principle, aligned with the modern jurisprudence of the courts of accounts, recognizes that true economy must consider the total cost of ownership (Total Cost of Ownership - TCO) and the externalities generated by the contract. A company that offers products with greater durability, lesser environmental impact and that generates local jobs may present a proposal with a higher nominal price, but deliver significantly greater public value when all the direct and indirect impacts of the contract are considered. As Floriano de Azevedo Marques Neto highlights:

It is no longer possible to understand the bidding process as a ritual of observance of forms and deadlines, detached from the realization of concrete public purposes. The attachment to formalism, still so present in Brazilian administrative culture, needs to yield space to a conception of public contracting as an instrument for the promotion of results, in which the criterion of the lowest price ceases to be absolute and gives way to the multidimensional analysis of the most advantageous proposal. This change imposes new competences on the public manager, who must be capable of assessing social, environmental and economic impacts, and equally challenges the control bodies to develop more sophisticated assessment methodologies, apt to measure the effective public value generated by the contract (MARQUES NETO, 2019, p. 57).

The cultural transformation underlying this paradigmatic change cannot be underestimated. Public managers, historically conditioned to privilege the lowest price as a safeguard against questioning by control bodies, need to develop new competences to assess multidimensional proposals. Companies accustomed to competing exclusively via price must restructure their business models to genuinely incorporate the values of sustainability and social responsibility. The control bodies themselves face the challenge of developing auditing methodologies that capture the complexity of this new reality, overcoming sterile formalism in favour of a substantive analysis of the public value generated.

The integrity programme required by Law 14.133/2021 functions as a catalyst of this transformation, establishing a minimum level of corporate governance that gradually raises the standard of the supplier market. Companies that initially see such a requirement as a bureaucratic obstacle progressively discover that the structuring of robust compliance systems not only qualifies them to contract with the public power, but also increases their competitiveness in the private market, reduces costs with litigation and contingencies, and attracts investors increasingly attentive to ESG criteria. Thus, a virtuous circle is created in which the public requirement induces private improvements which, in turn, raise the quality of public procurement.

The consolidation of the enterprise as a partner in the generation of public value represents, in the final analysis, the maturing of a systemic vision of public procurement.²⁰ The artificial dichotomy between public and private is overcome to recognize that, in a complex and interdependent economy, the success of one depends inexorably on the success of the other.²¹

The citizen enterprise is not the one that abdicates its profit objective, but the one that understands that the sustainable maximization of shareholder value necessarily passes through the creation of shared value with society.²² The State, in turn, abandons the posture of authoritarian buyer to assume the role of orchestrator of an ecosystem where different

²⁰ The idea of a strategic partnership between the State and companies reflects the advancement of a contemporary conception of public governance, which shifts the focus from mere formalist control to the pursuit of concrete results. In this model, public procurement ceases to be seen as an isolated act and comes to be understood as public policy in action, converging with international recommendations from the OECD and the European Union on *public procurement for innovation*.

²¹ Justen Filho notes that administrative contracts, under the regime of Law No. 14,133/2021, take on the role of inducing desirable economic and social behaviors, overcoming the old dichotomy between private efficiency and public purpose. The institutional economics literature also corroborates this view, showing that cooperative interaction between the State and the market tends to generate better sustainable development outcomes.

²² The concept of the "corporate citizen", developed by Juarez Freitas, conveys the notion that the modern corporation must align its economic performance with the constitutional objectives of social justice and environmental protection. This means that profit ceases to be an absolute end and becomes a means of generating shared value, internalizing positive externalities and mitigating negative impacts on the social and environmental fabric.

actors contribute, each with its specific competences, to the attainment of the common good. Floriano de Azevedo Marques Neto highlights that the State, in exercising its purchasing power, must act as an “inducer and orchestrator of a governance ecosystem”, and not as a mere centralizing buyer. This dialectical synthesis between private efficiency and public purpose configures the promising horizon of public procurement in the 21st century.

Reports from the World Bank (2021) and the OECD (2020) recognize that sustainable contracting, associated with programmes of integrity, innovation and social responsibility, configures one of the main agendas of administrative reform in the 21st century. The wager on a dialectical model, combining private efficiency and public purpose, is pointed out as essential to confront global challenges such as climate change, social inequalities and digital transformation. In this scenario, public procurement ceases to be a mere administrative function to consolidate itself as a structuring instrument of global governance, capable of redefining standards of production and consumption, strengthening economic democracy and ensuring the effectiveness of fundamental rights on an intergenerational scale.

3 FINAL CONSIDERATIONS

The consolidation of an ecosystem of sustainable public procurement demands the affirmation of a legal-administrative rationality that overcomes the traditional command-and-control model—centred on procedural formalism—and reconducts it to the logic of collaborative governance, results-based management and accountability. In the light of the 1988 Constitution, public procurement ceases to be an end in itself to become an instrument for the realization of constitutional objectives and rights: (i) the fundamental objectives of the Republic (Art. 3), (ii) the economic order founded on social justice and national sustainable development (Art. 170, caput and VI), (iii) the fundamental right to the ecologically balanced environment (Art. 225) and (iv) the principles of public administration (Art. 37, caput), with emphasis on legality, impersonality, morality, publicity and efficiency.

Within this framework, Law No. 14.133/2021 densifies the constitutional requirement by: (a) positivizing sustainability as a principle (Art. 5) and as an objective of the bidding process (Art. 11, IV); (b) linking the notion of advantageousness to life-cycle analysis and to the total cost of ownership (TCO); and (c) requiring, in large-scale contracts, the institution of integrity programmes as a condition of eligibility and of contractual execution (Art. 25, § 4). Integrity, therefore, is not a compliance adornment: it is a structuring principle of the legal regime of contracting and an element of the practical validity and democratic legitimacy of public spending.

From this arise three central legal propositions. (i) Finalistic constitutionalization of public procurement: bidding processes and contracts are means to deliver public value and to internalize environmental, social and economic externalities, the isolated criterion of the “lowest price” no longer being acceptable when it contravenes the useful result required by Art. 11 of Law No. 14.133/2021. Advantageousness acquires a material and measurable content (LCC/TCO, performance, innovation), compatible with the duty of good administration. (ii) Integrity as a condition of legitimacy and efficiency: public and corporate integrity reduces informational asymmetries, mitigates risks (legal, reputational, socio-environmental) and protects legitimate trust. On the contractual level, it must integrate: a) a risk-allocation matrix (identification, treatment and optimal apportionment); b) performance-based clauses; c) monitoring and auditing with verifiable indicators; and d) proportionate sanctions (including bonus-malus mechanisms), so as to align incentives and responsibilities. (iii) Public-private co-responsibility under collaborative governance: the State exercises a dual role—regulator (defining requirements, metrics and controls) and exemplar (implementing public compliance, internal controls, accountability and active transparency). It falls to companies to internalize ESG standards, maintain integrity programmes proportionate to risk, manage the supply chain and innovate to maximize public value, leaving the position of mere supplier for that of institutional partner.

In operational terms, the administrative contract comes to be understood as public policy in action. Its essential elements include: (a) robust planning (technical studies, market analysis, definition of socio-environmental requirements and indicators); (b) judgment criteria adherent to sustainable development and technical quality; (c) a clear risk matrix, with objective allocation, rebalancing triggers and proportionate guarantees; (d) monitoring by environmental, social, integrity and economic indicators, with M&V and independent auditing; and (e) continuous accountability to control bodies and to society. This arrangement reduces litigiousness, qualifies public expenditure and generates intertemporal gains, including fiscal ones, by prioritizing value in the life cycle.

The analysis developed throughout this study reveals that the Brazilian public procurement system finds itself in a process of profound transformation, redefining the way in which State, companies and society interact in the contractual arena. It is not a matter of mere legislative updating: Law No. 14.133/2021 inaugurates a new legal structure that repositions integrity and sustainable development at the centre of the administrative contract, requiring not only normative compliance, but a genuine change of practices, mentalities and organizational cultures.

This transition, however, faces significant barriers. The logic still predominant in public administration values form to the detriment of result, preserving the primacy of the lowest price even in the face of proposals capable of generating broader social and environmental benefits. The fear of personal accountability, added to the political influence over technical decisions, reinforces such a conservative tendency and limits the reach of the advantageousness criterion in its complete acceptance. On the other side, control bodies remain concentrated on documentary verification, without sufficient instruments to assess the public value effectively delivered by contracting. As Maurício Tamer and Rodrigo Pironti observe, it is urgent to overcome the logic of reciprocal distrust between State and market and to substitute it with a relationship of cooperation oriented toward common objectives, in which the private sector is recognized as an indispensable cog for the realization of public policies.

The Brazilian State, which moves about 15% of the national GDP through its procurement, has an unparalleled inducing capacity to orient business practices, stimulate innovation and disseminate sustainable standards of production. However, this transformative power remains underused due to institutional fragmentation, the lack of integrated planning and technical deficiencies present both in the public sphere and in the private sector. The challenge is to build a shared mentality that aligns managers and companies with the realization of the constitutional objectives of sustainable development, combining efficiency and integrity as inseparable principles.

To consolidate the new model, three fronts of action stand out and connect to the legal design outlined above. The first is the creation of an environment of legal certainty that ensures backing for managers who innovate in a technical and reasoned manner, avoiding that risk aversion paralyse the administration. The second consists of investing in the interdisciplinary training of teams, expanding the capacity for dialogue with economics, the environment and the assessment of public policies, including with the use of data, indicators and verifiable goals. The third demands the recognition of companies as partners in the generation of public value, with effective monitoring systems that allow measuring the real impacts of contracting on social inclusion, environmental protection and economic efficiency.

The current context is favourable to change. The new legal framework, allied to the international pressure for sustainable practices and to the urgency of environmental and social challenges, creates conditions for real transformation. Comparative experience, however, demonstrates that legal reforms, without cultural changes and institutional strengthening, produce superficial effects. Success will be measured by the capacity to convert norms into verifiable results: reduction of emissions, inclusion of vulnerable groups

in the labour market, balanced regional development and strengthening of local and innovative production chains.

The construction of a sustainable and honest public procurement system is not a contingent choice, but a constitutional duty inscribed in Arts. 3 and 170 of the Constitution. National sustainable development, the reduction of inequalities and the defence of the environment constitute mandates that bind all State action and find in public procurement one of the most powerful instruments of realization. Law No. 14.133/2021, in dialogue with international commitments such as the 2030 Agenda—especially SDG 16—, traces the normative path for this transformation. It now falls to overcome resistances, invest in institutional capacity and cultivate the courage necessary to break with consolidated practices, assuming the risks inherent in administrative innovation.

In sum, to contract well is to govern well. The legal duty of integrity, sustainability and efficiency converts State purchasing power into a legitimate vector of national sustainable development, making the contractual ecosystem a space of co-responsibility and production of public value compatible with the 1988 Constitution and with Law No. 14.133/2021. More than a technical advance of administrative law, the articulation among State, business and integrity represents the reconfiguration of the very function of the contract as an instrument for the realization of constitutional values and the promotion of the common good. This is the promise inscribed in the new legal framework; the challenge—and the shared responsibility—is to transform it into everyday practice.

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SWOT ANALYSIS IN AGRIBUSINESS: IDENTIFYING OPPORTUNITIES AND CHALLENGES FOR AGTECHS

ANÁLISE SWOT NO AGRONEGÓCIO: IDENTIFICANDO OPORTUNIDADES E DESAFIOS PARA AGTECHS

ANÁLISIS SWOT EN EL AGRONEGOCIO: IDENTIFICANDO OPORTUNIDADES Y DESAFÍOS PARA AGTECHS



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ABSTRACT

The article explores the application of SWOT analysis in Agtechs to identify strategies for growth and innovation. Using a qualitative methodology, the study evaluates strengths, weaknesses, opportunities, and threats in Brazilian agribusiness. The results highlight the importance of integrating innovative practices and improving technological processes to accelerate sustainable growth. It concludes that SWOT analysis is a decisive tool for the strategic direction of agricultural technology startups, promoting the transformation and modernization of the sector.

Keywords: Strategic Planning. Innovation. Sustainable Growth. Agricultural Technology.

RESUMO

O artigo explora a aplicação da análise SWOT em Agtechs para identificar estratégias de crescimento e inovação. Utilizando uma metodologia qualitativa, o estudo avalia forças, fraquezas, oportunidades e ameaças no agronegócio brasileiro. Os resultados destacam a importância de integrar práticas inovadoras e aprimorar processos tecnológicos para acelerar o crescimento sustentável. Conclui-se que a análise SWOT é uma ferramenta decisiva para o direcionamento estratégico das startups de tecnologia agrícola, promovendo a transformação e modernização do setor.

Palavras-chave: Planejamento Estratégico. Inovação. Crescimento Sustentável. Tecnologia Agrícola.

RESUMEN

El artículo explora la aplicación del análisis SWOT en Agtechs para identificar estrategias de crecimiento e innovación. Utilizando una metodología cualitativa, el estudio evalúa fortalezas, debilidades, oportunidades y amenazas en el agronegocio brasileño. Los resultados destacan la importancia de integrar prácticas innovadoras y mejorar los procesos tecnológicos para acelerar el crecimiento sostenible. Se concluye que el análisis SWOT es

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una herramienta decisiva para el direccionamiento estratégico de las startups de tecnología agrícola, promoviendo la transformación y modernización del sector.

Palabras clave: Planificación Estratégica. Innovación. Crecimiento Sostenible. Tecnología Agrícola.

1 INTRODUCTION

SWOT analysis is a widely used tool for evaluating the strengths, weaknesses, opportunities and threats of organisations and sectors, and it is extremely relevant to the current scenario of agricultural technology startups (agrotech). In Brazil, the significant growth of startups, driven from the 2000s onwards (GITAHY, 2011) and more intensely observed from 2018 onwards (ABSTARTUPS, 2022), highlights not only the diversification of business models – which vary between the Scalable, Small Business, Large Company, Lifestyle, Buyable and Social Startups categories (CONTAAZUL, 2016) – but also the need to understand the specific challenges and potentialities of each segment, especially that of Agtechs.

The Brazilian agricultural sector, which represents around 25.5% of GDP and benefits from unique conditions such as the high availability of arable land (CIEB, 2022; Rodrigues, 2006), has been incorporating innovations that permeate all the processes of the production chain, from genetic manipulation to the use of robotics and AI (WALTZ, 2017; MASSRUHÁ e LEITE, 2017). These technologies enable the integration and automation of agricultural processes, contributing to increased productivity and reduced costs, while at the same time mitigating environmental impacts and promoting operational efficiency.

In view of this scenario, the research problem to be investigated can be outlined as follows: how can the application of SWOT analysis contribute to the identification of growth and innovation strategies for Agtechs, considering the strengths present in the modernisation of Brazilian agribusiness and the threats and weaknesses arising from the structural and cultural limitations historically associated with entrepreneurship in the country? This question arises in a context in which Brazil, despite its innovative potential, has historically been marked by a restrictive view of entrepreneurship (GITAHY, 2011) and faces the challenge of competing with more developed ecosystems, such as that of the United States.

Based on the evidence presented, the hypothesis guiding this investigation proposes that the effective use of SWOT analysis will enable the structured identification of the strengths and opportunities inherent to Agtechs, making it possible to develop strategies that minimise weaknesses and threats and thus promote sustainable growth and the consolidation of innovation in the sector. This study will therefore seek to confirm whether the SWOT approach can be a decisive instrument in the strategic direction of agricultural technology startups, contributing to the transformation and modernisation of Brazilian agribusiness (Dutia, 2014).

In summary, the present research is grounded in the need to explore the benefits of SWOT analysis for the construction of innovative strategies in Agtechs, objectively identifying the elements that drive or restrict the development of the sector in the country.

2 LITERATURE REVIEW

The study by Ramos e Pedroso (2021) highlights the significant growth of agricultural technology startups in Brazil, demonstrating the innovative potential of Agtechs in the modernisation of agribusiness and the reduction of production costs. Significant strengths were identified, such as the wide availability of arable land and the intensive use of advanced technologies, which drive the sector. At the same time, there are weaknesses related to the historical structure and culture of entrepreneurship in the country, affecting the scalability of business models. The application of SWOT analysis made it possible to map opportunities for the development of strategies that address the competitiveness and sustainability of the sector. The results indicate that the integration of innovative practices and the improvement of technological processes can accelerate the sustainable growth of Agtechs. Thus, the findings demonstrate that a strategic approach, grounded in the analysis of internal strengths and deficiencies, is essential to the advancement of Brazilian agribusiness.

The research by Soares e Jacometti (2015) showed that innovative and sustainable strategies have added value to the Brazilian agribusiness sector. They observed an effective integration of advanced technologies into the production chain, enhancing competitiveness. The analyses revealed that combining investments in infrastructure and technological innovation raises productivity. Opportunities were identified for the development of management models based on SWOT analysis, maximising strengths and mitigating weaknesses. The importance of practices that align the modernisation of agriculture with environmental sustainability was also noted. These results point to the need for integrated efforts between the public and private sectors to consolidate agribusiness on a global stage.

The study by Martyniuk e Khodakivska (2022) demonstrated that the digitalisation of the agricultural sector emerges as a determining factor for increasing the productivity and efficiency of private enterprises. It was found that, despite the significant potential of the available resources, the performance indices of Ukrainian enterprises still fall short of those achieved in countries with greater technological and institutional support, such as Germany. The SWOT analysis highlighted significant strengths, such as the wide availability of land and labour, contrasted with weaknesses related to the scarcity of investments and legislative support. It was observed that the integration of digital technologies – notably in automation and data management processes – optimises operations and reduces operating costs. The

results point to the need to strengthen public policies that encourage the modernisation and improvement of technological processes in agribusiness. Thus, the strategic implementation of digitalisation emerges as a key element for boosting the competitiveness and sustainable growth of the agricultural sector.

The application of SWOT analysis integrated with the Business Model Canvas makes it possible to clearly identify the strengths, weaknesses, opportunities and threats in the vertical farming business model. It was observed that the incorporation of advanced technologies and the automation of processes are decisive factors for enhancing the competitiveness and operational efficiency of the sector. The results point to the centrality of sustainable aspects, both environmental and social, in the consolidation of innovative strategies. It was identified that continuous investments in technological infrastructure favour the reduction of costs and the generation of added value. The research emphasises the importance of strategic partnerships and a systematic view of market changes, which strengthens the proposal for sustainable growth. Thus, the findings indicate that the integrated approach of SWOT analysis with other management tools fosters the transformation and modernisation of Brazilian agribusiness (MALEKI, 2022).

The study by Silva (2021) investigates the influence of strategic planning versus the practice of innovation on the business performance of Agtechs, seeking to determine which factor is more decisive for the success of these companies. The methodology adopted is qualitative, with a multi-case study involving the analysis of primary and secondary data. The results indicate that there is no consensus on which factor is more important, but that the combination of agile planning with incremental innovations and conventional planning with disruptive innovations may be more effective. The research highlights the importance of strategic planning as a daily decision-making tool to increase the chances of success.

3 METHODOLOGY

3.1 SWOT ANALYSIS

SWOT analysis – an acronym for Strengths, Weaknesses, Opportunities and Threats – is a fundamental strategic tool for evaluating the positive and negative aspects of a business, considering both internal and external factors. This approach, widely used in case studies and academic research, enables a comprehensive understanding of the business environment, contributing to the formulation of sound and well-grounded strategies (Hofrichter, 2021).

Within the scope of internal factors, strengths represent the positive attributes of the organisation, whether tangible or intangible, that confer competitive advantages over

competitors. These attributes, which are under the company's control, may range from advanced technological processes to excellence in customer service. It is essential that the organisation exploits these strengths to maintain a prominent position in the market, as well as to mitigate potential weaknesses (Silva, 2011). For example, an analysis carried out by Fantoni (2016) showed that, in the civil engineering sector with a focus on sustainable technologies, factors such as the significant reduction in construction execution time and the fixed contract, which allows the client to know the total cost in advance, constitute major competitive advantages.

On the other hand, weaknesses represent the internal limitations that may compromise performance and the achievement of goals. They manifest themselves in the form of inefficient processes, failures in internal communication or the poor distribution of responsibilities, placing the company at a competitive disadvantage. Martins (2007) emphasises that the recognition and critical analysis of these deficiencies are essential for the implementation of improvements and for the maintenance of sustainable performance in the long term. A practical example is observed in a French school in São Paulo, where discontinuity in management, the lack of clear definition of employees' roles and the difficulty in retaining students were identified as critical points (Martins, 2007).

With regard to external factors, opportunities arise as favourable elements that can be exploited to leverage the company's growth. Such opportunities may stem from the emergence of new markets, technological changes or even governmental policies that promote financing and incentives. In Fantoni's (2016) study on the civil engineering company, relevant opportunities were identified, such as the expansion of housing finance programmes, society's growing interest in sustainable practices, the housing deficit and the potential to operate in differentiated market niches.

Finally, threats constitute the external challenges that may adversely impact the growth and stability of the company. These factors range from intense competition, which may consolidate the position of rival brands, to economic crises and the possibility of piracy or imitation of the business model. Martins (2007) warns that the continuous monitoring of these threats is crucial so that the organisation can develop preventive and reactive strategies, minimising the risks inherent to its operating environment. A practical example of threat analysis was verified by Dias (2018) in a delivery company in Bahia, where problems such as informality in sales, the consolidation of competition, customer dissatisfaction, the risk of copying the business model and financial instability were identified.

In short, SWOT analysis presents itself as an indispensable tool for understanding the factors that influence the performance of an organisation. By integrating the evaluation of

internal strengths and weaknesses with external opportunities and threats, managers have a strategic vision that enables them to anticipate challenges, enhance strengths and implement continuous improvements. In this way, SWOT analysis not only underpins strategic decisions, but also provides an environment of constant evolution and adaptation in an increasingly competitive market. It is important to emphasise that the correct application of this methodology can be decisive for the success and sustainability of a company in the long term.

3.2 GENERAL ENVIRONMENT AND TASK ENVIRONMENT

SWOT analysis, as Manktelow e Carlson (2010) point out, consists of the detailed evaluation of the external and internal situations that impact the achievement of an organisation's objectives. According to the authors, opportunities and threats refer to the circumstances of the external environment that influence the vision and the challenges for achieving goals, while strengths and weaknesses concern the internal characteristics that reveal the advantages and disadvantages in the pursuit of the desired results. In summary, the application of SWOT analysis enables the detailed identification of both the adversary and the conditions of the environment, contributing to the definition of a sound strategic positioning and an effective action plan.

For the definition of the variables to be analysed and compared in the different areas of operation of Agtechs, the concepts of general environment and task environment were used, as proposed by (CHIAVENATO e SAPIRO, 2020). According to this author, the general environment—or macroenvironment—encompasses the conditions that affect, directly or indirectly, all organisations in a generic way, constituting a scenario of common conditions inherent to the market.

Technology is a product of science and engineering, involving a set of instruments, methods and techniques aimed at solving problems. Thus, technological development, whether generated internally or coming from other organisations, has a direct impact on the innovation and competitiveness of the company, even though it is an area subject to uncertainties regarding its future.

In addition to technology, legal conditions play a fundamental role in the operationalisation of companies, insofar as current laws and regulations positively or negatively influence commercial behaviours, working conditions and supervision, among other aspects. Likewise, political aspects—related to the context and ideological definitions at the federal, state and municipal levels—may contribute to stability or generate instability in the economic and institutional conditions of the country, directly affecting business activities.

In the field of economic issues, permanent or temporary factors that influence the country's development, such as prices, profitability, supply and demand, exert a direct impact on the functioning and sustainability of companies. In addition, demographic aspects, which encompass variables such as population growth rate, geographical distribution, and ethnic and religious composition, provide subsidies so that organisations can monitor market characteristics and anticipate future trends.

Ecological conditions also play an important role, as they encompass physical and natural aspects—such as pollution, climate and logistics—that externally surround the company, allowing the business to be both affected by and to influence its ecosystem. Finally, cultural aspects, which encompass the knowledge, traditions and behaviours of a social group, are manifested in language, cuisine, music and the arts in general, as Oliveira (2022) points out. These cultural elements are indispensable so that companies can map the interests and behaviours of their consumers, both current and potential.

In summary, understanding the various elements that make up the general and task environment is fundamental to the effective application of SWOT analysis. By integrating knowledge about opportunities, threats, strengths and weaknesses, organisations are better equipped to define successful strategies, ensuring a competitive positioning and effectiveness in the execution of their action plans.

3.3 THE TASK ENVIRONMENT

The internal environment of a company, also called the operations environment, comprises the sectors and elements with which the organisation interacts directly, significantly influencing the achievement of its goals and objectives (Daft, 2003). This operational space is fundamental to the efficiency and development of the business, as it involves relationships that directly impact productivity and organisational performance.

Among the crucial components of this environment, the importance of suppliers stands out first. They are responsible for supplying the inputs necessary for the functioning of the company, including raw materials, capital, technology and human resources. Dependence on efficient and committed suppliers largely determines the organisation's ability to maintain the quality and continuity of its operations.

Another essential element concerns customers or users, who consume the products and services generated by the business activity. Understanding the needs and expectations of this public enables the company to adjust its offering and develop competitive advantages that ensure their loyalty and satisfaction, contributing to the sustainable growth of the business.

Competitors also make up this internal environment, although their influence comes from outside the direct control of the company. The presence of organisations that offer similar services or products stimulates competitiveness and forces the company to constantly improve its strategies in order to stand out in the market.

Finally, regulatory entities play an indispensable role in defining the rules and regulations that guide business activities. Examples of this group are trade unions, class associations and government regulatory bodies, which act in the supervision and standardisation of the sector, ensuring that operations are carried out within a framework of legal and ethical compliance.

In summary, the internal environment of the company is composed of a set of relationships and elements that, together, shape the operational efficiency and competitive capacity of the business. Each component, from suppliers to regulatory bodies, performs a function that, if well managed, can provide the ideal conditions for the success and sustainable growth of the organisation.

4 RESULTS AND DISCUSSION

4.1 COMPARING THE DIFFERENT AREAS OF OPERATION WITH THE SWOT METHODOLOGY

After data collection, in which the location of the Agtechs was addressed along with their operational and conceptual differences in each area of operation, the systematisation of the areas of operation was carried out through SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats).

SWOT analysis aims to identify strengths, weaknesses, opportunities and threats, being fundamental for providing a good database for strategic decision-making and a better direction for agribusiness startups.

In this set, the general environment and the task environment were defined. According to Daft (2003), the general environment consists of a series of external conditions and elements that surround and diffusely influence all companies. Thus, this environment exerts an indirect impact on the daily operations of these companies. In this way, the main identifiable variables in the general environment are: technological, legal, political, economic, demographic, ecological and cultural conditions.

The task environment, according to Daft (2003), corresponds to the most immediate and closest segment of the general environment. This task environment encompasses the sectors with which the organisation interacts directly and which exert a direct impact on the organisation's ability to achieve its objectives. In this way, the main identifiable variables in

the task environment are: input suppliers, customers or users, competitors and regulatory entities.

According to Ferrell e Hartline (2009), the main contributions of this methodology are:

1. The simplicity of SWOT analysis makes it accessible, requiring only a basic understanding of the company and its sector, without the need for extensive training or technical skills to be used successfully.
2. It offers lower costs, since it does not require specialised training, thus reducing the costs associated with strategic planning.
3. Its flexibility makes it possible to improve the quality of strategic planning, even without extensive marketing information systems. This means that SWOT analysis can be effective regardless of the availability of detailed information.
4. SWOT analysis integrates and synthesises a variety of information, both qualitative and quantitative, from various sources. This transforms the diversity of information into an advantage, strengthening the strategic planning process.
5. It facilitates collaboration and the exchange of information between managers of the different functional areas, promoting a more holistic and integrated approach to the organisation's strategic planning.

In this way, for each area of operation, the SWOT methodology was applied, with the purpose of evaluating the internal and external characteristics of agribusiness startups. Thus, the area of operation with the greatest prominence is decision support technologies, which have as strengths, as shown in Table 6:

1. **Agricultural efficiency:** It contributes to optimising the use of resources, in addition to increasing productivity and reducing operating costs.
2. **Customisation:** This technology seeks to serve each customer in a personalised way, adapting the innovation to each type of crop, climatic conditions, space and availability of resources, which becomes an advantage over those technologies that only meet specific needs.
3. **Access to real-time data:** It keeps the farmer always up to date, even without being present in the field, allowing them to check the progress of production and making decision-making more agile.

With regard to weaknesses, the following were analysed:

1. **Initial costs:** The initial implementations require a high investment, due to the complexity of the technological infrastructure and periodic maintenance.
2. **Need for connectivity:** As it is an integrated and automated technology, it is necessary for the connection in the field to be of good quality, as the performance of the technology depends on this factor.
3. **Learning:** The adoption of the technology by farmers or future customers may depend on familiarity with the new technologies. Those who do not have frequent contact may be reluctant to adopt new solutions, which may limit market reach.

Analysing the opportunities and threats of this area of operation, we have as opportunities:

1. **Market expansion:** Due to Agriculture 4.0, the agricultural sector is undergoing several changes. The search for new technologies has become increasingly recurrent, generating a growing demand. Being a rising market, the chances of growth are increasingly greater.
2. **Sustainability:** The demand for increasingly sustainable agricultural systems has been growing, and technologies are great allies in the pursuit of agriculture with less impact on the environment.

When it comes to threats, three main types were analysed:

1. **Regulation:** Changes in government regulations related to agriculture and technology may create uncertainties and increase compliance costs for the solution provider.
2. **Competition:** As it involves innovation, the emergence of new players may generate competition in the market, especially when there are differences in cost and quality, impacting profits and market share.
3. **Technological failures:** It involves a small share of errors that may occur during use, interfering in the final result.

Table 1

SWOT of the decision support technologies area

Strengths	Weaknesses	Opportunities	Threats
Agricultural Efficiency (Oliveira, 2022)	Initial Costs (Nascimento, 2022)	Market Expansion (Oliveira, 2022)	Regulation (Nascimento, 2022)

Customization	Need for connection (Oliveira, 2022)	Sustainability	Competition (Zambalde, 2011)
Access to real-time data (Massruhá, 2015)	Learning (Souza, 2019)		Technological failures (Massruhá, 2015)

Source: Prepared by the authors.

In the second area of operation, which is growing the most among Agtechs, we have management software, with great prominence for driving a more modern and sustainable agriculture. Thus, as shown in Table 7, the strengths are:

1. **Integration with other technologies:** Capacity for integration with precision agriculture devices, such as soil sensors, agricultural drones and automated equipment, providing efficient management of agricultural operations.
2. **Rural administration:** It collaborates in improving agricultural management, during day-to-day processes and also in the control of production, financial resources and tax obligations, making all processes more efficient.

On the other hand, as weaknesses:

1. **Digital infrastructure:** Connection problems in the field become frequent, due to vulnerability to interruptions in the power supply and connection failures, limiting the performance of the software.
2. **User knowledge:** Generally, producers have limited knowledge about the functioning of new digital tools, making the learning process incomprehensible for new users, which may become a barrier to acquiring these tools in agricultural production.

The opportunities that this area of operation presents are:

1. **Consumer market in the digital age:** Agriculture has also shown itself to be increasingly integrated with technologies, enabling the emergence of agricultural e-commerce, and online marketplaces are providing new channels for the sale and purchase of agricultural products, expanding markets for both producers and consumers. Finally, awareness of sustainability is opening space for more responsible and eco-friendly agricultural practices, creating opportunities for products and services related to sustainable agriculture.

2. **Training in digital agriculture:** Due to farmers' lack of familiarity with these tools, the provision of training and courses becomes a possibility, enabling more producers to acquire these new technologies.

With regard to threats, the following stand out:

1. **Cybersecurity risks:** Due to the growing digitalisation and automation in the agricultural sector, these agricultural digital systems may also contain sensitive data, such as information on crops, agricultural practices, financial data and farmers' personal information. The theft of these data may lead to privacy issues.

Table 2

SWOT of the management software area

Strengths	Weaknesses	Opportunities	Threats
Integration with other technologies (Bambini, 2015)	Digital infrastructure (Milanez, 2020)	Consumer market in the digital environment (Zambalde, 2011)	Cybersecurity risks (Bambini, 2015)
Rural Management (Ramos, 2022)	User knowledge (Sordi, 2020)	Training in digital agriculture (Bolfe, 2020)	

Source: Prepared by the authors.

The smart equipment and hardware area of operation, as shown in Table 8, has as strengths:

1. **Operational efficiency:** The purpose of this smart equipment is to significantly improve production, automating tasks and optimising the use of resources. Through this equipment, it is possible to reduce spending on fertilisers, harvest time and disease identification, contributing to the better performance of agriculture.
2. **Precision and monitoring:** Smart sensors and devices offer greater precision and real-time monitoring capacity, allowing more accurate management of agricultural operations.

The weaknesses are as follows:

1. **Development:** The design and development of the equipment consists of a long process that begins with the identification of the need and the challenges faced, in which the feasibility of implementing the technology will be studied. This requires a large investment of financial capital for this equipment to reach the market.

2. **Maintenance:** The maintenance of smart equipment in agriculture is a crucial aspect for ensuring the effectiveness, reliability and longevity of these technological systems. However, this maintenance generates a cost for the producer, which may result in non-compliance with periodic maintenance, affecting the useful life of the equipment.

The opportunities presented in this area of operation are:

1. **Logistics:** The logistics process between producers and traders may generate losses in production, whether through inadequate storage, loss of quality during transport or loss of quantity. Thus, smart equipment may provide optimisation and modernisation of logistics in the field, assisting in real-time tracking, route optimisation and stock management, always ensuring the best processes to maintain the quality and quantity of production.
2. **Waste reduction:** Through the implementation of smart equipment and hardware, the opportunity is offered to reduce waste, both in the use of agricultural inputs and in losses during harvest and the distribution process. This equipment can be implemented for monitoring climatic conditions, pests and diseases that may directly affect production yield, in addition to providing a more precise harvest.

Regarding the threat involved in this area of operation, the following can be mentioned:

1. **Connectivity in the field:** It may expose the vulnerability of smart devices, which may suffer data theft attacks, interruptions of operations and interference in connectivity. In order to minimise these risks, practices must be adopted that ensure greater security for the producer.

Table 3

SWOT of the smart equipment and hardware area

Strengths	Weaknesses	Opportunities	Threats
Operational efficiency (Junior, 2021)	Development (Vicente, 2002)	Logistics (Ramos, 2022)	Field connectivity (Milanez, 2020)
Precision and monitoring (Bolfe, 2020)	Maintenance (Vicente, 2002)	Waste reduction (Vargas, 2013)	

Source: Prepared by the authors.

With regard to the precision agriculture area of operation, its SWOT analysis was carried out, as shown in Table 9, containing as strengths:

1. **Greater fertility:** Due to the technologies used, such as sensors and GPS, it is possible to map and identify each space to increase productivity at the site. In addition, there is greater pest control, so that they do not interfere in production and cause significant losses.
2. **Waste reduction:** In the processes of applying inputs and pesticides, there is a great deal of waste. However, due to precision agriculture, waste reduction has become increasingly frequent. There is equipment that identifies areas with weeds, applying chemical products only to the affected areas.
3. **Automation:** Through precision agriculture, all field processes, such as planting, application of inputs and harvesting, can be optimised, generating greater productivity. As an example, we can mention smart planting, in which it is important to know how many seeds to plant and the distance between them, since when planted too close together, they may compete for sun and nutrients.

The weaknesses are as follows:

1. **Specialised labour:** Due to the technical complexity of precision agriculture, the demand for specialised workers is increasingly frequent, as it is necessary to have solid knowledge about the technologies and tools used in the field so that production becomes increasingly efficient.
2. **Implementation:** For farmers with limited resources, the implementation costs may be an obstacle to the adoption of the technology. Therefore, this technology is limited to large producers.

As opportunities in the precision agriculture area of operation, there are:

1. **Reduction of environmental contamination:** The pursuit of reducing environmental impacts is an increasingly important trend in agribusiness, due to the need for biodiversity conservation and the conscious use of natural resources. In this way, precision agriculture promotes the reduction of input application, which, when applied incorrectly, may harm the plant and the soil. In addition, the use of smart irrigation systems makes it possible to reduce water waste.

2. **Rapid decision-making:** The implementation of the technology allows access to monitoring and control tools, enabling the farmer to have access to crop data in real time. This makes it possible to create more assertive planning, enabling the reduction of risks and the optimisation of production.

Finally, as threats, there are:

1. **Climatic risks:** Due to climatic instability, fluctuations in temperature and rainfall may hinder the performance of the implemented technologies, causing a decrease in productivity.
2. **Economic viability:** The implementation of technology in the field is a process that requires initial investments, covering only large producers. This reduces the market niche, making the technology less accessible for small producers, who end up opting for the traditional method.

Table 4

SWOT of the precision agriculture area

Strengths	Weaknesses	Opportunities	Threats
Greater fertility (Resende, 2010)	Specialized labor (Souza, 2019)	Reduction of environmental contamination (Resende, 2010)	Climate risks (Bassoi, 2019)
Waste reduction (Resende, 2010)	Implementation (Gomide, 2001)	Fast decision-making	Economic viability (Bassoi, 2019)
Automation			

Source: Prepared by the authors.

With regard to the agribusiness consultancy area of operation, the SWOT analysis was carried out, as shown in Table 10, with the following strengths:

1. **Personalised approach:** For each segment of the agri market, specific planning is necessary to meet the demands of the area. In this way, consultancy, in addition to providing improvements for production, seeks a personalised approach for each client, in which technical recommendations are adapted to local conditions, such as soil type, climate, crop and water availability.
2. **Future projections:** Through data analysis, it is possible to measure future perspectives, analysing trends, economic aspects, market projection, among others. With these

perspectives, it is possible to have a direction for the strategies that will be used to optimise processes.

With regard to weaknesses, there is:

1. **Dependence on human resources:** Agribusiness consultancy is still highly dependent on human labour. To obtain results, continuous monitoring is necessary, which means that the demand for professionals in this area is high, generating a scarcity in the market.

As opportunities identified in the agribusiness consultancy area, we have:

1. **Education and training:** In addition to providing the consultancy service, providing the basic knowledge for the producer is extremely important for maintaining a good operation. In this way, by expanding the consultancy service to training and education of producers regarding their needs in their production, topics such as good agricultural practices, business management and the use of new technologies can be addressed, generating better use of local productive resources.
2. **Diversification in the market:** Agribusiness consultancy offers various services to support producers in achieving better results in their already established production, but the implementation of new crops may be the key to ensuring better results and also the efficiency and profitability of their activities.

As threats involving the agribusiness consultancy area, there is:

1. **Economic and political instability:** The fluctuation in the prices of agricultural commodities may affect the profitability of producers and, consequently, their capacity to invest in consultancy services. In addition, global crises may hinder access to foreign markets, and the devaluation of various crops may also occur.

Table 5

SWOT of the agribusiness consultancy area

Strengths	Weaknesses	Opportunities	Threats
Personalized approach (Nunes, 2021)	Dependence on human resources (Souza, 2019)	Education and training (Bolfe, 2020)	Economic and political instability (De Carvalho, 2023)
Future projections		Market diversification	

Source: Prepared by the authors.

Regarding the agricultural marketing area of operation, the SWOT analysis was carried out and the following aspects were identified:

Strengths:

1. **Superior quality:** With technological advances and the growing demand for quality food, it is necessary to use means that ensure this parameter. Thus, the biofortification of food becomes a differential for increasing the content of micronutrients, such as vitamins and minerals, and can be done through genetic manipulation or through fertilisation.
2. **Storage:** To ensure the best post-harvest conditions of the product, the storage process is essential to avoid significant losses in production. With this, the implementation of technological tools enables greater control of humidity, temperature and sanitisation.

Weaknesses:

1. **Agility in the distribution of products:** Logistics processes are fundamental to ensure that the product reaches the final consumer with quality. In this way, transport with safety and quality becomes a barrier to achieving better marketing of products, as volume, distance and price are the main challenges of agricultural logistics.
2. **Access to the international market:** The lack of marketing in international markets can be explained by the exchange rate and also by import taxes. Thus, regulatory issues do not encourage aspects of international marketing.

Opportunities:

1. **ESG certification:** In order for agricultural marketing to comply with environmental, social and governance parameters, these must be implemented throughout the production chain. With this, products that have ESG certification present greater credibility and also boost their marketing.
2. **Digitalisation of marketing:** To make marketing faster and more dynamic, having an e-commerce platform aimed at the main distributor markets may result in an improvement, in which purchase and payment can be made through the platform.

Threats:

1. **Inflation:** Inflation may have a significant impact on marketing, affecting both producers and consumers, and may affect production costs, the prices of agricultural products and consumer demand.
2. **Climate change:** The instability of climatic conditions becomes a threat to production and directly affects marketing, since, in most cases, producers are not prepared for this type of situation.

Table 6

SWOT of the agricultural marketing area of operation

Strengths	Weaknesses	Opportunities	Threats
Superior quality	Agility in product distribution (Gaban, 2017)	ESG Certification	Inflation
Storage (Gaban, 2017)	Access to the international market (Alves, 2007)	Digitalization of commercialization (E-commerce) (Prado, 2020)	Climate change (Basso, 2019)

Source: Prepared by the authors.

Finally, the SWOT analysis of the food security area of operation was carried out, in which the following strengths were recognised:

Strengths:

1. **Global relevance:** Food insecurity is recognised as a significant global problem, requiring increasing efforts in the search for effective solutions. Its relevance has encouraged interest in the development of new technologies that can assist in combating this challenge.
2. **Public and private partnerships:** In order to contemplate Sustainable Development Goal number 2, which consists of eradicating hunger and promoting sustainable agriculture, having both public and private allies is fundamental to intensifying the strategies promoted.
3. **Microbiological analyses:** With the performance of microbiological analyses, it is possible to ensure the safety and quality of food, preventing contaminated food from reaching the consumer, providing greater hygiene conditions.

Weaknesses:

1. **Food distribution:** The logistics processes involved so that food reaches all segments of the population present several stages, in which, during distribution, there may be failures and losses, hindering access.
2. **Dependence on suppliers:** To ensure that food reaches everyone, it is necessary to have a reliable network of suppliers that can ensure a continuous and adequate supply of food. The lack of an efficient logistics process may lead to significant losses.

Opportunities:

1. **Waste reduction:** In Brazil, food distribution is inadequate, which generates waste. In this way, waste reduction is essential to provide an improvement in the management of the supply chain, allowing food that would be destined for the rubbish to be redistributed to vulnerable populations or those in a situation of food insecurity.
2. **Food education in schools:** It is a fundamental strategy to promote greater awareness about the proper use of food and correct nutritional knowledge, enabling healthier and more conscious choices. In addition, introducing teaching about the importance of reducing food waste.

Threats:

1. **Pests and diseases in crops:** The presence of pests and diseases in agricultural production may compromise food security, resulting in a decrease in the quality of food, interruption in the supply chain and food waste.
2. **Scarcity of natural resources:** Natural resources are fundamental for food production, and their scarcity generates significant losses in production, impacting the distribution of food to the population. For this reason, the search for sustainable management practices is increasingly required to reduce the impacts of the use of natural resources.

Table 7

SWOT of the food security area of operation

Strengths	Weaknesses	Opportunities	Threats
Global Relevance (Vasconcelos, 2005)	Food distribution (Caixeta Filho, 2021)	Waste reduction (Vargas, 2013)	Pests and diseases in crops
Public and private partnerships (Cotta, 2013)	Dependence on suppliers	Food education in schools (Verthein, 2021)	Scarcity of natural resources (Maniglia, 2020)

Therefore, the SWOT analysis of the Agtechs' areas of operation highlights a robust internal environment, with significant strengths. Agricultural efficiency is a highlight, optimising resources, increasing productivity and reducing operating costs. The customisation of technological solutions caters to different types of crop and climatic conditions, while access to real-time data enables quick and informed decisions. In addition, smart equipment contributes to operational efficiency and waste reduction.

However, these strengths are counterbalanced by internal challenges. High initial costs represent a significant barrier, as does the need for a high-quality connection in the field. The adoption of new technologies requires training and familiarity, which may be an obstacle for many farmers. Digital infrastructure and the need for specialised labour are also weaknesses that need to be addressed.

In the external environment, the opportunities are vast. Market expansion, driven by Agriculture 4.0, and the growing demand for sustainability offer great potentialities. The digitalisation of the agricultural market and e-commerce open new possibilities for marketing, while access to the international market and public and private partnerships strengthen food security and sustainability.

However, the threats should not be underestimated. Changes in government regulations may create uncertainties and increase costs. Competition is growing, with new players entering the market. Cybersecurity risks, adverse climatic conditions and economic and political instability also represent significant challenges.

5 CONCLUSIONS

The study demonstrated the relevance of SWOT analysis as a strategic tool for the Agtechs sector, identifying strengths, weaknesses, opportunities and threats that shape the business environment. The application of the methodology enabled a comprehensive understanding of the internal and external dynamics, making it possible to develop more effective strategies adapted to the context of Brazilian agribusiness. The integrated analysis of critical factors contributes to more robust strategic planning aligned with market needs.

The limitations of the study lie in the qualitative approach, which, although in-depth, may not be generalisable to all contexts of Agtechs in Brazil. The limited sample of companies analysed and the specificity of the geographical regions considered may restrict the

applicability of the results. Future studies could explore a quantitative approach with a larger and more diversified sample to validate and expand the conclusions.

The contributions of the study are significant for the field of management and innovation in agribusiness, offering a practical framework for the strategic analysis of Agtechs. The identification of critical success factors and the challenges faced by companies in the sector provides important information for entrepreneurs, investors and policy-makers. The research also highlights the importance of continuous adaptation and innovation to ensure the competitiveness and sustainability of Agtechs.

It is concluded that the study reinforces the need for a strategic and integrated approach to the development of the Agtechs sector in Brazil, considering both internal and external aspects. SWOT analysis proved to be a valuable tool for decision-making and for planning actions aimed at sustainable growth and the consolidation of innovation in agribusiness.

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ABSTRACT

Digital transformation has become a strategic factor for the competitiveness of service organizations, enabling better operational traceability, fewer errors, and faster data-driven decision making (Laudon & Laudon, 2016). In Mexico, INEGI (2020) reports that 99.8% of the country's economic units are micro, small, and medium-sized enterprises (MSMEs), highlighting the need for affordable technological solutions aligned with real operational processes. University academic-administrative units face analogous problems: data scattered across spreadsheets, informal coordination through instant messaging, incomplete files, and limited auditability. To address this problem, the learning unit program management system was developed as an in-house web system for centralizing academic planning and Learning Unit Program (PUA) management. The solution was implemented using a decoupled architecture: Laravel in the backend, React in the frontend, and MySQL as the database engine, following the Model-View-Controller (MVC) pattern and exposed through a RESTful API (Fielding, 2000). The system integrates modules for faculties, degree programs, teachers, subjects, and competencies, with document versioning and automated PDF generation with SHA-256 integrity verification. Functional validation with end users evidenced substantial improvements: centralized subject search in seconds, modular editing with section-level persistence, and PDF versioning with historical traceability. The learning unit program management system demonstrates that tailored software development can outperform generic commercial software, providing functional control, economic feasibility, and direct alignment with institutional processes.

Keywords: Digital Transformation. RESTful API. Academic Management. Laravel. MySQL. Learning Unit Programs.

RESUMO

A transformação digital consolidou-se como um fator estratégico para a competitividade das organizações de serviços, permitindo maior rastreabilidade operacional, redução de erros e otimização da tomada de decisões baseada em dados (Laudon & Laudon, 2016). No México, o INEGI (2020) relata que 99,8% das unidades económicas do país correspondem a micro,

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pequenas e médias empresas (MPME), o que confirma a necessidade de soluções técnicas acessíveis e alinhadas com processos reais. As áreas académico-administrativas universitárias enfrentam problemáticas análogas: registos dispersos em folhas de cálculo, acompanhamento informal por mensagens instantâneas, processos incompletos e escassa capacidade de auditoria documental. Para atender a essa problemática, desenvolveu-se o sistema de gestão de programas de unidade de aprendizagem, um sistema web in-house orientado a centralizar o planeamento académico e a gestão dos Programas de Unidade de Aprendizagem (PUA). A solução foi implementada com uma arquitetura desacoplada: Laravel no backend, React no frontend e MySQL como motor de base de dados, seguindo o padrão Model-View-Controller (MVC) e exposto através de uma API RESTful (Fielding, 2000). O sistema integra módulos para faculdades, cursos, docentes, disciplinas e competências, com mecanismos de versionamento e geração automática de documentos PDF com verificação de integridade SHA-256. A validação funcional com utilizadores finais evidenciou melhorias substanciais: centralização da consulta académica em segundos, edição modular com persistência por secção e versionamento PDF com rastreabilidade histórica. O sistema de gestão de programas de unidade de aprendizagem demonstra que o desenvolvimento sob medida pode superar as limitações do software genérico, oferecendo controlo funcional, viabilidade económica e alinhamento direto com os processos institucionais.

Palavras-chave: Transformação Digital. API RESTful. Gestão Académica. Laravel. MySQL. Programas de Unidade de Aprendizagem.

RESUMEN

La transformación digital se ha consolidado como factor estratégico para la competitividad de las organizaciones de servicios, permitiendo mayor trazabilidad operativa, reducción de errores y optimización en la toma de decisiones basada en datos (Laudon & Laudon, 2016). En México, el INEGI (2020) reporta que el 99.8% de las unidades económicas del país corresponden a micro, pequeñas y medianas empresas (MIPYMES), lo que confirma la necesidad de soluciones técnicas asequibles y alineadas con procesos reales. Las áreas académico-administrativas universitarias enfrentan problemáticas análogas: registros dispersos en hojas de cálculo, seguimiento informal por mensajería instantánea, expedientes incompletos y escasa capacidad de auditoría documental. Para atender dicha problemática, se desarrolló el sistema de administración de programas de unidad de aprendizaje, un sistema web in-house orientado a centralizar la planeación académica y la gestión de los Programas de Unidad de Aprendizaje (PUA). La solución fue implementada con una arquitectura desacoplada: Laravel en el backend, React en el frontend y MySQL como motor de base de datos, siguiendo el patrón Model-View-Controller (MVC) y expuesto a través de una API RESTful (Fielding, 2000). El sistema integra módulos para facultades, carreras, docentes, materias y competencias, con mecanismos de versionado y generación automática de documentos PDF con verificación de integridad SHA-256. La validación funcional con usuarios finales evidenció mejoras sustanciales: centralización de la consulta académica en segundos, edición modular con persistencia por sección y versionado PDF con trazabilidad histórica. El sistema de administración de programas de unidad de aprendizaje demuestra que el desarrollo a la medida puede superar las limitaciones del software genérico, ofreciendo control funcional, viabilidad económica y alineación directa con los procesos institucionales.

Palabras clave: Transformación Digital. API RESTful. Gestión Académica. Laravel. MySQL. Programas de Unidad de Aprendizaje.

1 INTRODUCTION

Higher education institutions manage a considerable volume of academic and administrative information which, in terms of operational complexity, is comparable to that of a small or medium-sized service enterprise: high turnover of records, dependence on internal approvals, and the need for timely responses to audits or institutional reviews (Laudon & Laudon, 2016; Pressman & Maxim, 2020). The persistence of manual procedures in this context is not an isolated phenomenon; INEGI (2024) documents that a significant proportion of MSMEs in Mexico still carry out record-keeping processes without digital support, a tendency that is replicated in academic-administrative environments.

Before the implementation of the learning unit program management system, the academic planning processes at the Facultad de Ingeniería of the Universidad Autónoma de Campeche were carried out through physical notebooks, scattered office files, and coordination messages in mobile applications. This scheme caused data duplication, low traceability of changes, and excessive dependence on the tacit knowledge of operational staff, which Pressman and Maxim (2020) identify as one of the main sources of operational debt in organisations with non-formalised workflows.

The persistence of manual procedures generated three main risks: (1) *operational risk*—prolonged times to locate files, consolidate academic workloads, or verify the status of competencies—; (2) *information quality risk*—inconsistencies between sources and data-entry errors due to the absence of a single point of truth—; and (3) *continuity risk*—when the responsible staff were unavailable, the recovery of the working context proved slow and costly.

As an alternative, the use of third-party commercial software under a rental scheme was evaluated. However, this option presented limitations for the context analysed: recurring fixed costs, low flexibility to adapt specific academic catalogues, dependence on the provider's *roadmap*, and restrictions to incorporate its own logic for PUA management and curricular evidence. Under these criteria, the *in-house* development of a modular platform was technically justified (Pressman & Maxim, 2020).

This article describes the design, implementation, and evaluation of the learning unit program management system, a comprehensive web system for centralising university academic planning. The **general objective** was to design and implement a web system to manage academic planning, centralising key entities and automating the generation of supporting documents, with a scalable architecture based on Laravel, React, and MySQL. The **specific objectives** were:

1. Structure a relational data model for faculties, degree programs, teachers, subjects, and competencies.
2. Build a REST API for CRUD operations, contextual queries, and the PUA document workflow.
3. Implement a React interface oriented towards administrative productivity and module-based navigation.
4. Integrate a versioning and PDF generation mechanism to ensure documentary traceability.
5. Validate the usefulness of the system through functional and usability testing with end users.

The rest of the article is organised as follows: Section 2 presents the theoretical background; Section 3 describes the development methodology; Section 4 details the development of the system; Section 5 reports the results; Section 6 discusses the findings from a comparative perspective; and Section 7 presents the conclusions.

2 THEORETICAL BACKGROUND

2.1 DIGITAL TRANSFORMATION IN HIGHER EDUCATION INSTITUTIONS

Digital transformation is defined as the process by which organisations integrate digital technologies into all their functional areas, fundamentally modifying the way they operate and generate value (Laudon & Laudon, 2016). In the university context, this process involves not only the adoption of technological tools but also the redesign of academic and administrative processes to maximise the efficiency and quality of the educational service.

INEGI (2020) documents that 99.8% of the economic units in Mexico are MSMEs, whose operational structure shares characteristics with the academic-administrative areas of public universities: limited resources, high dependence on operational staff, and frequently non-standardised processes. The Business Demography Survey (INEGI, 2024) adds that the adoption of information technologies in these organisations remains heterogeneous, with significant gaps in the integration of document management systems.

2.2 ACADEMIC INFORMATION SYSTEMS

An information system (IS) is a set of interrelated components that collect, process, store, and distribute data to support decision making and control within an organisation (Laudon & Laudon, 2016). In the academic domain, specialised IS centralise the management of study programs, academic workloads, student records, and curricular

documentation, contributing to the reduction of processing times and the increase of data quality (Pressman & Maxim, 2020).

The document management of academic programs involves complex workflows of approval, versioning, and distribution. The absence of specialised tools forces institutions to depend on generic solutions—spreadsheets, email—that lack mechanisms for version control, auditing, and structured information retrieval (Date, 2004). This functional deficit is the origin of the operational risks identified in the diagnosis of the present study.

2.3 WEB ARCHITECTURES FOR INFORMATION SYSTEMS

The contemporary web development paradigm favours decoupled architectures where the *frontend* and the *backend* operate independently and communicate through well-defined interfaces (Fowler, 2002). In this model, the *backend* exposes services through a RESTful API (*Representational State Transfer*), while the *frontend* consumes these services to build the user interface.

REST is a software architecture style defined by Fielding (2000) in his doctoral dissertation, characterised by the absence of state on the server (*statelessness*), the client-server architecture, the layered system, and the uniform interface based on HTTP resources. An API that adheres to these principles is called RESTful and employs the standard HTTP methods (GET, POST, PUT, PATCH, DELETE) for operations on resources represented in JSON format.

The Model-View-Controller (MVC) pattern, formalised by Fowler (2002), establishes a separation of responsibilities into three components: the Model (business logic and data access), the View (presentation), and the Controller (coordination between Model and View). This pattern is the architectural foundation of modern frameworks such as Laravel for PHP (Laravel LLC, 2026), which also incorporates an ORM (*Object-Relational Mapping*) called Eloquent for the abstraction of database access. React, in turn, is a JavaScript library for building user interfaces based on reusable components that favours the declarative paradigm and the efficient handling of the virtual DOM (Meta Open Source, 2026).

2.4 RELATIONAL DATABASES AND AUTOMATED DOCUMENT GENERATION

The relational model, formalised by Date (2004), organises data into tables with explicit relationships defined by primary and foreign keys, guaranteeing referential integrity and transactional consistency. MySQL is a relational database management system (RDBMS) widely adopted in web applications, which implements the SQL standard and provides robust mechanisms for indexing, ACID transactions, and replication (Oracle Corporation, 2026).

The automatic generation of PDF documents from web applications is carried out through server-side rendering libraries. DomPDF is a PHP implementation that generates PDF documents from HTML templates with support for fonts, tables, and CSS styles, being suitable for academic documents with a standardised institutional format. The use of cryptographic *hash* functions (SHA-256) on the generated documents makes it possible to verify their integrity and detect unauthorised modifications (Pressman & Maxim, 2020).

3 METHODOLOGY

The development of the learning unit program management system was carried out through an iterative and incremental process aligned with the principles of agile software development (Beck *et al.*, 2001). Four main phases were defined that made it possible to advance from the diagnosis to validation with real users:

Phase 1 — Requirements gathering. Through semi-structured interviews with administrative staff and those responsible for academic planning, the operational needs of the system were identified. This qualitative method made it possible to capture both explicit functional requirements and implicit needs derived from the existing workflow (Pressman & Maxim, 2020).

Phase 2 — System design. The relational data model was developed through Entity-Relationship diagrams, the design of the REST API with the specification of endpoints and HTTP verbs, and the user interface prototypes. The model was normalised to the third normal form (3NF) to eliminate redundancies and guarantee referential integrity (Date, 2004).

Phase 3 — Implementation. The *backend* was developed with Laravel following the MVC pattern, exposing REST endpoints for CRUD operations and the PUA document workflow. The *frontend* was built as an SPA (*Single Page Application*) with React and Vite, consuming the REST API through asynchronous HTTP operations.

Phase 4 — Validation. Functional tests were carried out with real academic planning use cases and usability tests with end users. The evaluation verified the correct execution of the critical flows (creation, query, update, deletion, and document generation) in accordance with software quality criteria (ISO/IEC, 2011).

4 SYSTEM DEVELOPMENT

4.1 REQUIREMENTS GATHERING

Based on the semi-structured interviews conducted with administrative staff and users responsible for academic planning, ten fundamental operational needs were identified:

1. Manage faculties, degree programs, academies, and areas as master catalogues with referential integrity rules.
2. Register teachers with association to their position, access role, and academic affiliation.
3. Manage subjects with attributes of credits, theoretical hours, practical hours, subject type, core, and curricular relationship.
4. Incorporate generic and specific competencies linked to faculty and degree program.
5. Query subjects by degree program and study plan to reduce search times.
6. Provide institutional authentication to control access by module.
7. Edit PUA contents by sections, preserving progress and review status.
8. Issue PUA PDF documents with version control and historical download.
9. Allow the maintenance of bibliography and complementary data without altering the core of the system.
10. Maintain an open architecture for future functional extensions.

4.2 ARCHITECTURE AND TECHNOLOGIES

The solution was implemented under a decoupled client-server scheme (Fowler, 2002). The *frontend* was developed as an SPA with React and Vite, using reusable components and state management through *hooks*. The *backend* was built with Laravel, exposing HTTP endpoints for authentication, catalogues, and document management. MySQL was used as persistent storage with referential integrity (Oracle Corporation, 2026).

In the presentation layer, React Router organises navigation by modules: *login*, access panel, teachers, degree programs, subjects, competencies, library, and PUA processing. The interface consumes REST services through *fetch*, performing GET, POST, PUT, PATCH, and DELETE operations with JSON responses (Meta Open Source, 2026).

In the business layer, Laravel centralises validations, persistence rules, and the coordination of Eloquent models. The API includes routes representative of each domain: authentication (*POST /login*), academic management (*GET /materias*, *POST /carreras*, *DELETE /facultades/{id}*), and PUA workflow (*POST /api/pua/documentos*, *PUT /api/pua/documentos/{id}/modulos/{slug}*, *POST /api/pua/documentos/{id}/generar-pdf*). For the document layer, DomPDF was used, encapsulated in a dedicated service that reduces the coupling between the business logic and the document presentation (Fowler, 2002).

4.3 DATABASE DESIGN

The relational model was structured into three levels of abstraction (Date, 2004): base catalogues, academic operation, and PUA document management.

The **base catalogues** include the entities: Faculty, Area, StudyPlan, Academy, Position, SubjectType, Core, and Role. The **academic operation** comprises: Access (credentials and user role), Teacher (links academic identity with faculty, position, and access), Degree Program (associated with faculty and study plan), Subject (central entity with foreign keys to degree program, faculty, area, core, subject type, and academy), Generic Competency, and Specific Competency (support the structure of learning outcomes by curricular context).

The **PUA document management** is supported by three specialised tables: *pua_documentos* (defines the base document by degree program and subject, with metadata and review status), *pua_modulos* (persists editable document sections in JSON format by *slug*), and *pua_versiones* (records version, status, SHA-256 *checksum*, and the path of the issued PDF). This structure guarantees transactional consistency, avoids record duplication, and allows historical traceability of the academic document (Date, 2004).

The key business relationships established are:

1. Faculty 1:N Degree Program, Academy, Teacher, and Specific Competency.
2. Degree Program 1:N Subject and 1:1..N StudyPlan according to institutional configuration.
3. *pua_documentos* 1:N *pua_modulos* and 1:N *pua_versiones*.
4. Integrity reinforced by unique constraints on critical combinations (degree program-subject and document-slug).

4.4 PROGRAMMING LOGIC

The implementation adopts the Laravel MVC pattern to separate responsibilities (Fowler, 2002): the Model represents business entities and Eloquent relationships; the Controller receives HTTP requests, validates parameters, and coordinates CRUD operations; and the View is materialised as JSON responses for consumption by the decoupled *frontend*.

In React, the interface logic is organised by functional components and local state. The PUA processing module synchronises faculty-degree program-subject, creates or retrieves the active document, and persists each section as an independent module. This strategy improves data recovery, reduces the loss of progress, and enables incremental work between sessions.

The versioning flow operates in four stages: (a) consolidation of the modules persisted in the database, (b) *rendering* of the PDF template through DomPDF, (c) storage of the binary on local disk, and (d) recording of version metadata with a SHA-256 *checksum*. This sequence provides change control and integrity evidence for auditing, responding directly to the information quality and operational continuity risks identified in the diagnosis.

From an extensible design perspective, the document generation layer can be extended through the *Strategy* pattern (Gamma *et al.*, 1995), which encapsulates different generation algorithms (PDF, XLSX, HTML) in an interchangeable manner without modifying the controllers or the core domain. Input validations were incorporated in the *backend* and *frontend* to minimise inconsistent data. As an immediate improvement, it is recommended to reinforce authentication with standard cryptographic *hashing* (bcrypt or Argon2) and session policies with expiration times, in accordance with OWASP security best practices.

5 RESULTS

5.1 AUTHENTICATION MODULE

The access interface centralises institutional authentication and redirects the user to a panel according to their operational context. The screen reduces incorrect entries through prior format validation and handling of connection errors, improving the initial experience of the system. This module implements role-based access control, ensuring that each user views only the modules corresponding to their academic affiliation.

5.2 DASHBOARD AND OPERATION PANEL

The main panel integrates navigation by academic administration modules and sections of operational statistics. The visual structure prioritises high-frequency accesses, reducing idle times in query and data-entry tasks. The behaviour of the interface allows a rapid transition between academic control operations without leaving the working context, favouring the productivity of the administrative staff.

5.3 CRUD OF ACADEMIC ENTITIES

Complete forms and listings were implemented for teachers, degree programs, subjects, faculties, academies, competencies, and bibliography. The standardisation of these CRUD modules made it possible to consolidate previously scattered data, eliminate duplications, and establish a single repository of institutional information—a principle called *Single Source of Truth* (Fowler, 2002)—guaranteeing consistency in all system operations.

5.4 DOCUMENT AUTOMATION AND PDF VERSIONING

The PUA module allows the selection of faculty, degree program, and subject; each section of the program is saved by module and can be marked by review status (draft, under review, approved). Upon completion, the system generates a new downloadable PDF version, preserving the complete history of issuances for auditing and academic control. The SHA-256 *checksum* mechanism guarantees the integrity of the generated document and makes it possible to detect unauthorised modifications a posteriori.

5.5 VALIDATION WITH END USERS

Functional validation was carried out with real academic planning use cases: creation, query, update, deletion, and document generation. Usability tests with end users confirmed a substantial improvement in the understanding of the operational flow, especially in the tasks of curricular selection and PUA document issuance. Table 1 summarises the comparative operational impact observed.

Table 1

Comparativa de impacto operativo: esquema manual vs. PlaneaciónPUA.

Process	Previous scheme (manual)	Scheme with PlaneaciónPUA
Search for academic data	Relied on multiple scattered files and coordination via instant messaging	Centralized and structured query in seconds
Consolidation of the PUA	Fragmented data entry with high incidence of rework and loss of progress	Modular editing with per-section persistence and incremental accumulation of progress
Documentary evidence	Loose files without traceability or change control	PDF versioning with full history and SHA-256 verification
Operational continuity	Dependence on the individual knowledge of operational staff	Standardized workflow on a single platform, independent of individuals

Note. Elaborated by the authors based on validation with end users (2026).

Source: Prepared by the authors.

The overall result shows the resolution of the original problem: administrative friction was reduced, data quality was strengthened, and the responsiveness to internal requirements was increased. From a business perspective, this behaviour is equivalent to the expected benefit in an MSME that migrates from manual processes to an integrated digital platform (Laudon & Laudon, 2016).

6 DISCUSSION

The results obtained demonstrate the feasibility of the *in-house* development of academic information systems for university environments with limited resources. This feasibility contrasts with the widespread perception that tailored software is inaccessible for small and medium-scale organisations, which coincides with the findings of Pressman and Maxim (2020) regarding the differential value of well-designed software in contexts with specific operational needs.

The decoupled Laravel-React-MySQL architecture was validated as a robust and economically viable technological combination. Laravel facilitates the rapid development of RESTful APIs through its Eloquent ORM and its expressive routing system (Laravel LLC, 2026), while React provides a fluid user experience through the efficient management of the virtual DOM (Meta Open Source, 2026). MySQL offers transactional reliability and a mature relational model that supports the complexity of the relationships between academic entities (Oracle Corporation, 2026). This technological choice is consistent with Fowler's (2002) recommendations on the separation of responsibilities into layers as a central maintainability strategy.

The versioning mechanism with a SHA-256 *checksum* provides an auditing dimension that manual processes could not guarantee. This functionality responds directly to the information quality and operational continuity risks identified in the diagnosis phase, and aligns with the principles of documentary traceability required by institutional accreditation processes.

The main limitation identified in the current system is the authentication layer, which employs basic credential validation mechanisms. The implementation of cryptographic *hashing* (bcrypt or Argon2) and the adoption of JWT tokens (*JSON Web Tokens*) for session management are recommended, in accordance with the OWASP guidelines for enterprise web applications. This improvement is a priority given that the system safeguards sensitive academic information of the institution.

Regarding future lines of work, the following priority extensions were identified: (1) incorporation of usage analytics to identify work patterns and areas of continuous improvement; (2) extension of the functional ecosystem towards teacher evaluation and schedule planning; (3) development of operational intelligence dashboards for academic managers; and (4) implementation of automatic notifications for the follow-up of the PUA review flow. These lines are inscribed in the vision of a comprehensive academic management platform for the Facultad de Ingeniería of the Universidad Autónoma de Campeche.

7 CONCLUSIONS

The implementation of the learning unit program management system confirms the technical and operational feasibility of a tailored web solution to manage university academic planning with professional development standards. The decoupled Laravel-React-MySQL architecture, supported by a relational data model structured into three levels, made it possible to centralise critical processes and mitigate the risks of documentary dispersion, information duplication, and dependence on individual knowledge identified in the initial diagnosis.

In terms of operational value, the system optimised the times for data entry, query, and document issuance; reduced errors due to duplication or inconsistency; and provided change traceability through PDF versioning with integrity verifiable by SHA-256 *checksum*. These results are directly transferable to MSME-type contexts where administrative efficiency and information control represent competitive advantages (Laudon & Laudon, 2016).

The learning unit program management system demonstrates that *in-house* development, when supported by a solid iterative methodology (Beck *et al.*, 2001) and an architecture grounded in established software engineering patterns (Fowler, 2002; Gamma *et al.*, 1995), can outperform the limitations of generic software, providing functional control, economic feasibility, and direct alignment with institutional processes. The platform is considered stable for expanded institutional deployment and presents a high capacity for modular scaling towards the functionalities identified as future work.

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